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High Quality Seafoods

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On the cover: High quality seafood. See the article beginning on page 11. NMFS photograph.

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Predation by Marine Mammals on Squids of the Eastern North Pacific Ocean and the Bering Sea

CLIFFORD H. FISCUS

Introduction

When marine mammals (with the exception of a few cetaceans) forage for food over the continental shelf, fish usually comprise most of their prey. Along the continental slope fish and cephalopods are equally important, and in the deeper waters of the North Pacific Ocean and the Bering Sea squids form a major part of their diet. In the eastern North Pacific Ocean the neritic squid *Loligo opalescens* is the most important species preyed on by marine mammals over the continental shelf. However, the data available on consumption of squid by marine mammals have not been systematically reviewed.

Parts of this paper were originally prepared for a workshop on squids held at the Seattle Laboratory of the NMFS Northwest and Alaska Fisheries Center on 19-20 March 1981. The purpose of the workshop was to gather information on the squid resources of the region, principally from central California to the Bering Sea, for potential development of squid fisheries. The various species of squids were listed and described and information was presented on their distribution, seasonal abundance, commercial utilization, and position they play in the northeastern Pacific Ocean ecosystem.

This paper is an attempt to consolidate and make available information from several sources on the relationship between squids and their major marine mammal predators. Most of the small cetaceans, several of the large cetaceans, and most pinnipeds prey on squid and octopus when available.

Marine mammals inhabiting the eastern North Pacific Ocean and Bering Sea are listed in Table 1. Of the 45 marine mammals listed in Table 1, 26 are known to prey on squid or octopus in varying degrees, and it is quite likely that many of the remaining 20 may also prey to some extent on these cephalopods. Major predators are discussed here.

Important sources of information on the predator-prey relation between marine mammals and squids of the epipelagic, mesopelagic, and the continental shelf waters in the eastern North Pacific Ocean are the annual reports of agencies of the United States (National Marine Fisheries Service, NOAA) and Canada (Department of the Environment) on pelagic fur seal research carried out during 1958-74. These reports provide information on species identified from stomachs of northern fur seals, and general locations where these seals were taken. In the past several years, data

Table 1.—Marine mammals of the eastern North Pacific Ocean, Bering, and Chukchi Seas. Those known to prey on cephalopods are marked with an asterisk (*). (Names are after Rice, 1977.)

Common name	Scientific name	Common name	Scientific name
Walrus	*Odobenus rosmarus*	Spotted dolphin	*Stenella attenuata**
California sea lion	*Zalophus californianus**	Striped dolphin	*Stenella coeruleoalba**
Northern sea lion	*Eumetopias jubatus**	Saddleback dolphin	*Delphinus delphis**
Northern fur seal	*Callorhinus ursianus**	Pacific whiteside dolphin	*Lagenorhynchus obliquidens**
Guadalupe fur seal	*Arctocephalus townsendi*	Northern right whale dolphin	*Lissodelphis borealis**
Sea otter	*Enhydra lutris**	Whitehead grampus	*Grampus griseus**
Harbor seal	*Phoca vitulina richardsi**	False killer whale	*Pseudorca crassidens**
Spotted or larga seal	*Phoca largha**	Shortfin pilot whale	*Globicephala macrorhynchus**
Ringed seal	*Phoca hispida**	Killer whale	*Orcinus orca*
Ribbon seal	*Phoca fasciata**	Harbor porpoise	*Phocoena phocoena*
Bearded seal	*Erignathus barbatus*	Dall's porpoise	*Phocoenoides dalli**
Northern elephant seal	*Mirounga angustirostris**	Belukha	*Delphinapterus leucas**
Gray whale	*Eschrichtius robustus*	Sperm whale	*Physeter macrocephalus**
Minke whale	*Balaenoptera acutorostrata*	Pygmy sperm whale	*Kogia breviceps**
Bryde whale	*Balaenoptera edeni*	Dwarf sperm whale	*Kogia simus**
Sei whale	*Balaenoptera borealis*	North Pacific giant bottlenose whale	*Berardius bairdii*
Fin whale	*Balaenoptera physalus*	Goosebeak whale	*Ziphius cavirostris**
Blue whale	*Balaenoptera musculus*	Ginkgo-tooth whale	*Mesoplodon ginkgodens*
Humpback whale	*Megaptera novaeangliae*	Archbeak whale	*Mesoplodon carlhubbsi*
Right whale	*Balaena glacialis*	Bering Sea beaked whale	*Mesoplodon stejnegeri*
Bowhead whale	*Balaena mysticetus*	Densebeak whale	*Mesoplodon densirostris*
Rough-toothed dolphin	*Steno bredanensis**		
Bottlenose dolphin	*Tursiops truncatus**		
Spinner dolphin	*Stenella longirostris**		

Clifford H. Fiscus is with the National Marine Mammal Laboratory, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way, N.E., Seattle, WA 98115.

from this research have been combined and compiled in a series of reports (North Pacific Fur Seal Commission, 1962, 1969, 1971, 1975, 1980; Lander, 1980; Perez[1]; and Perez and Bigg[2].

Two abundant small cetaceans (Dall's porpoise and Pacific white-sided dolphin) and the northern fur seal inhabit the same subarctic waters and consume essentially the same species of squids (Kajimura et al., 1980). Antonelis and Fiscus (1980) briefly discussed the food and feeding habits of pinnipeds of the California Current. Some demersal species were found in the stomachs of collected specimens, evidencing that these pinnipeds, including the fur seal, and the two small cetaceans which feed primarily in surface and near surface waters on epipelagic and mesopelagic species, also feed over the continental shelf and descend to the bottom.

Several other small cetaceans are abundant in tropical and subtropical waters and two of them, the saddleback dolphin and the shortfin pilot whale, range northward into the southern fringe of the region discussed here. Reilly (1977) summarizes the available information on feeding habits of the pilot whale. He describes five population centers for this species; the northernmost (Californian) stretches from about San Francisco Bay, Calif., to northern Baja California, Mexico. This population may feed mostly on the squid *Loligo opalescens*. The saddleback dolphin is most abundant from the California Bight southward and also preys heavily on squids.

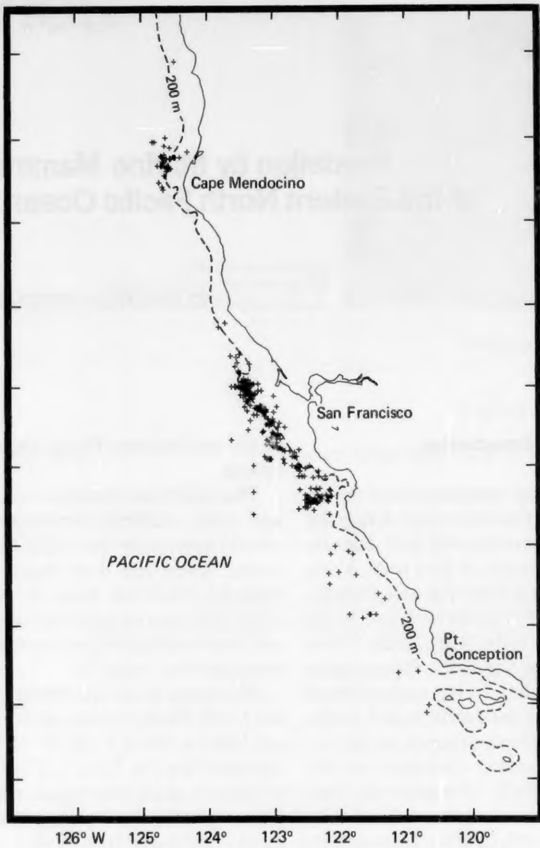


Figure 1.—Locations off California where northern fur seals were collected whose stomachs contained *Loligo opalescens*.

Most information on bathypelagic and benthic squids has been obtained by examining the stomach contents of several species of toothed whales, primarily the sperm whale taken by commercial whalers and from specimens stranded on beaches.

Methods

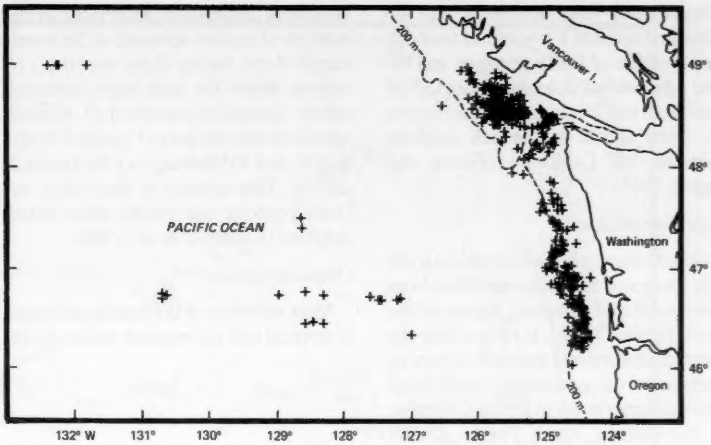
Collection of Specimens

Fur seals were taken at sea by the United States and Canada during 1958-74. Collections were made in seven areas as follows: 1) California, December to June 1958-66; 2) Oregon, January to May 1958-65; 3) Washington, December to June 1958-74; 4) British Columbia, January to July 1958-72; 5) Gulf of Alaska, February to August 1958-68; 6) Western Alaska, May to October 1958-68; and 7) Bering Sea, May to November 1958-74. Because the cephalopod fauna of Oregon, British Columbia, and Western Alaska is similar to adjoining areas, only four of the areas

[1]Perez, M. A. 1979. Preliminary analysis of feeding habits of the northern fur seal in the eastern North Pacific Ocean and Bering Sea, 1958-74. *In* H. Kajimura, R. H. Lander, M. A. Perez, A. E. York, and M. A. Bigg, Preliminary analysis of pelagic fur seal data collected by the United States and Canada during 1958-74. Natl. Mar. Mammal Lab., Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way, N.E., Seattle, WA 98115. (Submitted to 22d Annual Meeting of the North Pacific Fur Seal Commission.) Unpubl. rep., p. 167-232.

[2]Perez, M. A., and M. A. Bigg. 1980. Interim Report on the feeding habits of the northern fur seal. *In* H. Kajimura, R. H. Lander, M. A. Perez, A. E. York, and M. A. Bigg, Further analysis of pelagic fur seal data collected by the United States and Canada during 1958-74, Part 2. Natl. Mar. Mammal Lab., Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way, N.E., Seattle, WA 98115. (Submitted to 23d Annual Meeting of the North Pacific Fur Seal Commission.) Unpubl. rep., p. 4-172.

Figure 2.—Locations off Washington where northern fur seals were collected whose stomachs contained *Loligo opalescens*



are discussed. See the annual reports mentioned previously for methods of taking.

Dall's porpoise, Pacific white-sided dolphin, and several other small cetaceans (saddleback dolphin and killer whale) were also taken at sea during fur seal research cruises (see Kajimura et al., 1980, for description of taking).

Sperm whales taken commercially off central California by commercial whalers from 1956 to 1971 (Rice, 1974 and pers. commun.) were examined at the Richmond, Calif., stations and stomach contents retained for identification at the National Marine Mammal Laboratory (NMML) in Seattle, Wash.

Stomach contents of stranded specimens were collected as they became available and identified in the NMML. Squid remains in stomachs ranged from relatively intact and undigested whole specimens to undigestable hard parts such as the gladius, beaks, and statoliths. Unfortunately many identifications must be based on beaks alone. The head, base of arms and tentacles, and the buccal mass persist in a stomach longer than do other body parts, and this fragment can be useful in identifying a specimen at least to genus.

Squid beaks from the stomachs of marine mammals, fish, and birds usually can be identified to family. In some instances, however, species identifications can be made where no near relatives occur. For example, in the eastern North Pacific Ocean *L. opalescens* is the only representative of its family presently known to occur and *Onychoteuthis borealijaponicus* is the only representative of its genus. There are many species of gonatids and they cannot be identified with certainty from beaks alone; however, if the head and arms, and tentacles are relatively intact, identification usually can be made to genus. Within the past 20 years the numbers of species described in the family Gonatidae from the North Pacific Ocean and Bering Sea has more than doubled, and more species will likely be identified and described in the future.

The degree of digestion of prey items is important and should be considered when analyzing information on prey species from marine mammal stomachs. Whole or relatively undigested squids indicate consumption near the point of capture; however, beaks alone may represent accumulations of previous feedings and the animal could have traveled a considerable distance from where the prey was consumed. Prey identified from the stomachs of dead, stranded specimens usually provide little information on where prey was consumed. Squids, by family, are discussed below.

Squids Taken as Prey

Loliginidae

Loligo opalescens is the only species of this family identified from the northeastern North Pacific Ocean. It is found from the shore seaward over the continental shelf and slope within its range which extends from Mexico northward to British Columbia (Recksiek and Frey, 1978; Bernard, 1980). Young (1972) stated that *L. opalescens* probably is the most abundant cephalopod species off the California coast. Bernard (1980) mentions this squid as being present in large numbers in the shallow waters off British Columbia. It is locally abundant seasonally and is a major prey of fishes, seabirds, and most pinnipeds and small cetaceans throughout its range.

During all months in which fur seals were collected (January through June off California and December through June off Washington), *L. opalescens* was found in the stomachs of fur seals collected off California and Washington. Most fur seals that had consumed it were taken over the continental shelf and slope or a relatively short distance seaward of the slope. It was reported in the stomachs of six fur seals collected well offshore in the eastern part of the Gulf of Alaska; however, significant numbers have not been found in seals taken north of Hecate Strait, British Columbia. Locations where fur seals were collected whose stomachs contained *L. opalescens* are shown in Figures 1 (California) and 2

(Washington) (from Kajimura[3] and unpublished records[4]). It was also found in the stomachs of Dall's porpoise and Pacific white-sided dolphins collected off California and Washington (Kajimura et al., 1980) and in saddleback dolphins collected off California (Fiscus and Niggol, 1965).

Onychoteuthidae

Onychoteuthis borealijaponicus is the only species of this genus identified from transitional and subarctic waters of the North Pacific Ocean[5]. It ranges over the continental slope and seaward, occurring rarely over the continental shelf from Baja California north to British Columbia in the eastern North Pacific Ocean (Young, 1972). The stomachs of three seals taken off Kodiak Island in the Gulf of Alaska in April and May 1960 contained *O. borealijaponicus*; it is taken in surface gillnets in subarctic waters of the North Pacific Ocean south of western Alaska and the Aleutian Islands (footnote 4). In the western North Pacific Ocean, this species ranges north to the Kuril Islands and waters south of the western Aleutian Islands at least seasonally (Naito et al., 1977). It is a major prey of pinnipeds and cetaceans that forage in offshore epipelagic and mesopelagic zones.

It was identified from the stomachs of fur seals collected off California during all months in which fur seals were collected (January-June), and off Washington from January to June. None were reported off Washington in December but only 78 seals were taken during that month. Occurrences of *O. borealijaponicus* increased off Washington in April and May; however, this increase could have been the result of an increase in the number of cruises seaward of the continental slope during those months. Locations where fur seals were collected whose stomachs contained *O. borealijaponicus* are shown in Figures 3 (California) and 4 (Washington) (footnotes 3 and 4). This species is also taken by Dall's porpoise and Pacific white-sided dolphins (Kajimura et al., 1980).

Ommastrephidae

Most members of this family are found in tropical and subtropical waters south of the subarctic water mass except for *Ommastrephes bartramii* which apparently ventures across the subarctic boundary on occasion (Clarke, 1966; Young, 1972). While we have not identified *O. bartramii* from the stomachs of marine mammals collected in the eastern North Pacific Ocean, the species occurs at least seasonally as reported by Bernard (1980), and we have identified several specimens taken in gillnets by Pacific Salmon Investigation (NMFS Northwest and Alaska Fisheries Center) vessels south of the Aleutian Islands.

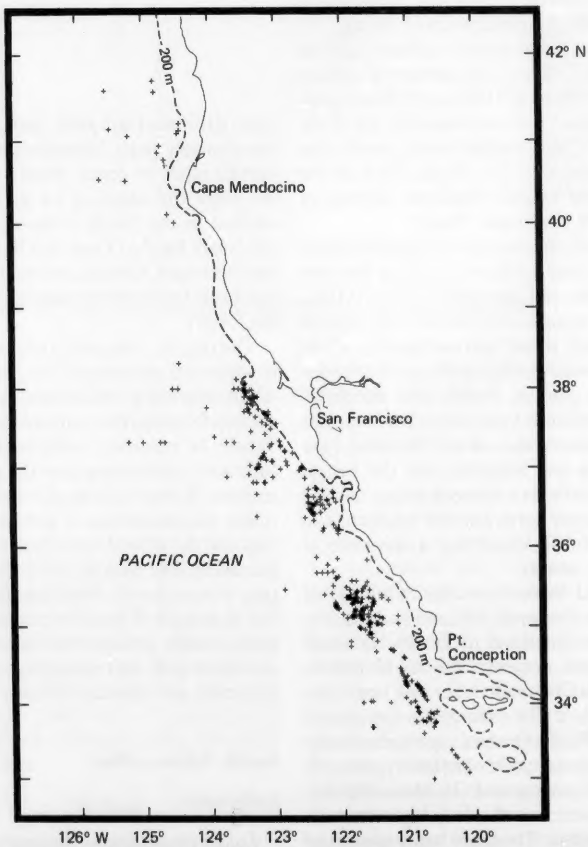


Figure 3.—Locations off California where northern fur seals were collected whose stomachs contained *Onychoteuthis borealijaponicus.*

[3]Kajimura, H. 1981. The opportunistic feeding of northern fur seals off California. Natl. Mar. Mammal Lab., Northwest and Alaska Fish. Cent., Natl. Mar. Fish Serv., NOAA, 7600 Sand Point Way, N.E., Seattle, WA 98115. Unpubl. rep., 46 p.

[4]Unpublished records of the National Marine Mammal Laboratory, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way, N.E., Seattle. WA 98115.

[5]The other recognized species in the genus, *O. banksii*, is apparently tropical or subtropical in the Pacific Ocean (Young, 1972).

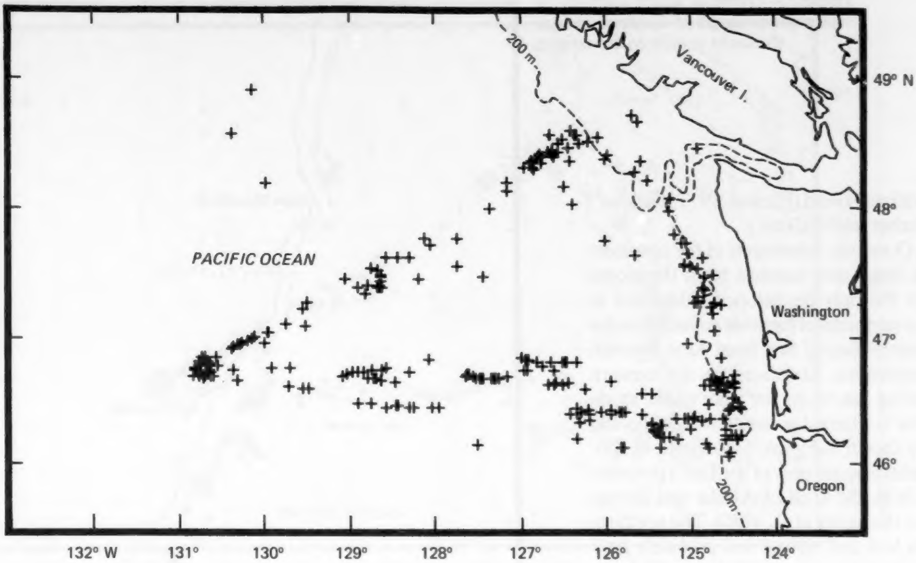


Figure 4.—Locations off Washington where northern fur seals were collected whose stomachs contained *Onychoteuthis borealijaponicus*.

Gonatidae

Three genera, *Gonatus, Berryteuthis,* and *Gonatopsis,* comprising about 12 species, represent this family in subarctic waters of the North Pacific Ocean and Bering Sea (Young, 1972; Okutani, 1973; Naito et al., 1977; Anderson, 1978; Bublitz, 1981; and Jefferts, 1981). It is extremely difficult or impossible at present to identify these species from beaks alone; therefore, this discussion will be restricted to the family level.

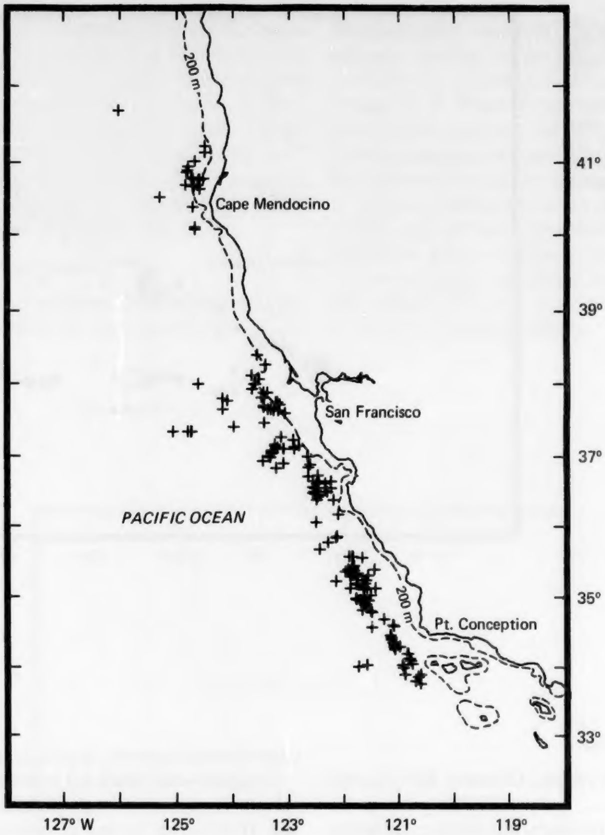
Members of this family are found principally from the continental slope seaward and in some inshore deepwater localities such as Prince William Sound, Alaska, and southeastern Alaska-British Columbia. Some individuals may be found at all depths from near the bottom along the continental slope to surface waters at night (Roper and Young, 1975). Pearcy et al. (1977) reported vertical migrations of three species of gonatids off Oregon (*Gonatus pyros, G. onyx,* and *Gonatopus borealis*), and most cephalopods captured (mostly juvenile and larval forms) were caught in the upper mesopelagic and epipelagic zones.

Gonatids were identified in the stomachs of fur seals collected off California and Washington during all months in which fur seals were collected (January-June off California, November-June off Washington). Off California, gonatids comprised a smaller portion of the fur seals' diet than did *L. opalescens* and *Onychoteuthis borealijaponicus*; however, they were well represented as prey of the Pacific white-sided dolphin and Dall's porpoise which may regularly feed at greater depths than do fur seals. Gonatids were well represented among squids identified from the stomachs of sperm whales taken by commercial whalers off central California in the 1960's (footnote 4). Sperm whales apparently were feeding near the bottom primarily along the continental slope and into deeper waters. Those taken by commercial whalers were collected within 60-100 n.mi. (110-185 km) of San Francisco Bay where the whaling stations were located.

Off Washington, gonatids were more evident in the fur seal's diet than off California and probably were as important as *O. borealijaponicus* seaward of the continental shelf. Gonatids were well represented in the prey of the Pacific white-sided dolphin and Dall's porpoise off Washington (Kajimura et al. 1980). Pike (1950) and Clarke and MacLeod (1980) reported Gonatidae from the stomachs of sperm whales taken off British Columbia. Locations where fur seals were taken whose stomachs contained gonatids off California and Washington are shown in Figures 5 and 6 (footnote 4).

Gonatids are an important prey of fur seals and the smaller cetaceans in the Gulf of Alaska from March through June over the outer continental shelf, the continental slope, and seaward. Locations where seals whose stomachs contained gonatids were collected in the Gulf of Alaska are shown in Figure 7 (footnote 4). Gonatids have been identified from the stomachs of northern sea lions and harbor seals collected in the northern Gulf of Alaska and Prince

Figure 5.—Locations where northern fur seals were collected off California whose stomachs contained Gonatidae.



William Sound (Pitcher, 1977; Calkins[6]; Pitcher and Calkins[7]).

Gonatids, inhabitants of the continental slope and seaward from the slope, are the only cephalopods identified in the stomachs of fur seals collected in the eastern Bering Sea from June through September. Locations in the eastern Bering Sea where fur seals whose stomachs contained gonatids were collected are shown in Figure 8 (footnote 4). Gonatids also are prey of the Dall's porpoise in both the Gulf of Alaska and Bering Sea (Kajimura et al., 1980). The northern sea lion and ribbon seal probably prey on gonatids along the continental slope. Lowry et al. (1977) report squids as important food of ribbon seals. Lowry et al. (1979), summarizing available information on feeding by the ice seals, reported squids were consumed by ribbon and spotted seals. We have a few records of gonatids from the stomachs of ringed seals taken in the Chukchi Sea (footnote 4). Octopus were reported from the stomachs of bearded and spotted seals. Johnson et al. (1966) identified octopus in the stomachs of a few ringed and bearded seals taken at Point Hope, Alaska, in the Chukchi Sea. Gonatids also formed a significant part of the food of sperm whales taken by Japanese and Soviet whalers in the Gulf of Alaska and Bering Sea (Table 2).

Results and Discussion

Some marine mammals are relatively restricted in their diet, regularly feeding on only a few types of prey. However, many of the toothed whales and those pinnipeds that range over the offshore and oceanic waters (as opposed to coastal species [Repenning, 1976]) are opportunistic feeders, perhaps attracted to certain localities or regions by seasonally abundant fishes and squids. Over the continental shelf, fishes comprise most of their diet, but along the continental slope (sometimes characterized by nutrient-rich upwellings) fish and squids are equally important prey. In oceanic waters squids are usually the most important prey.

At least nine squids have been identified from the stomachs of fur seals collected in the eastern North Pacific Ocean and Bering Sea (Table 3) and a small pelagic octopus, *Ocythoe tuberculata,* was identified in the stomachs of a few fur seals taken off southern California. Four of these squids, *Abraliopsis* spp., *Octopoteuthis* spp., *Moroteuthis robusta,* and *Chiroteuthis* spp., and the pelagic octopus *Ocythoe* were taken in relatively small numbers and did not contribute significantly to the fur seal's food in this region.

The northern fur seal, as well as many other marine mammals, is migratory. Thus, information gathered during pelagic fur seal studies, which was keyed to periods of seasonal abundance in certain localities, does not provide information on a year-round basis. For example, no

[6]D. G. Calkins, Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99502. Pers. Commun.

[7]Pitcher, D. W., and D. G. Calkins. 1981. Biology of the harbor seal, *Phoca vitulina richardsi*, in the Gulf of Alaska. Outer Continental Shelf Environmental Assessment Program Final Report. Juneau Project Office, P.O. Box 1808, Juneau, AK 99802.

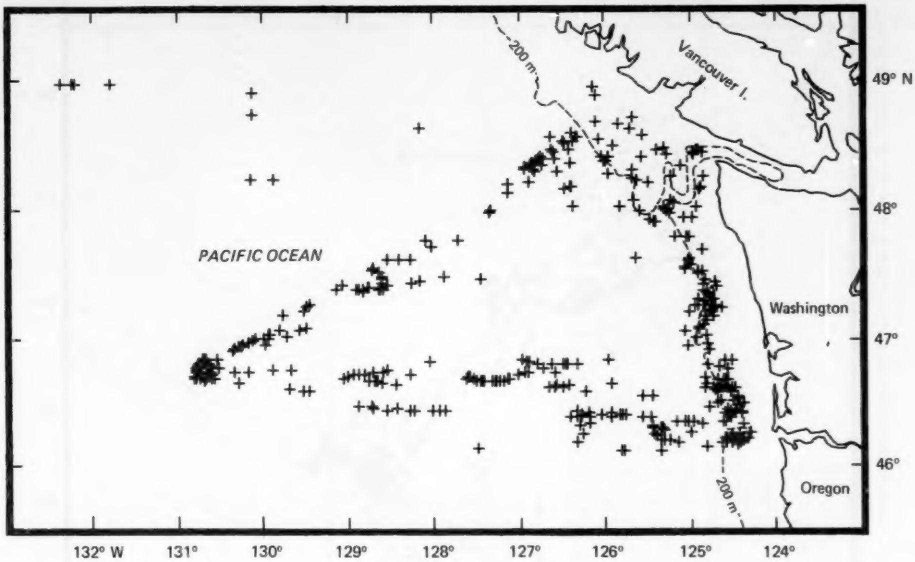


Figure 6.—Locations where northern fur seals were collected off Washington whose stomachs contained Gonatidae.

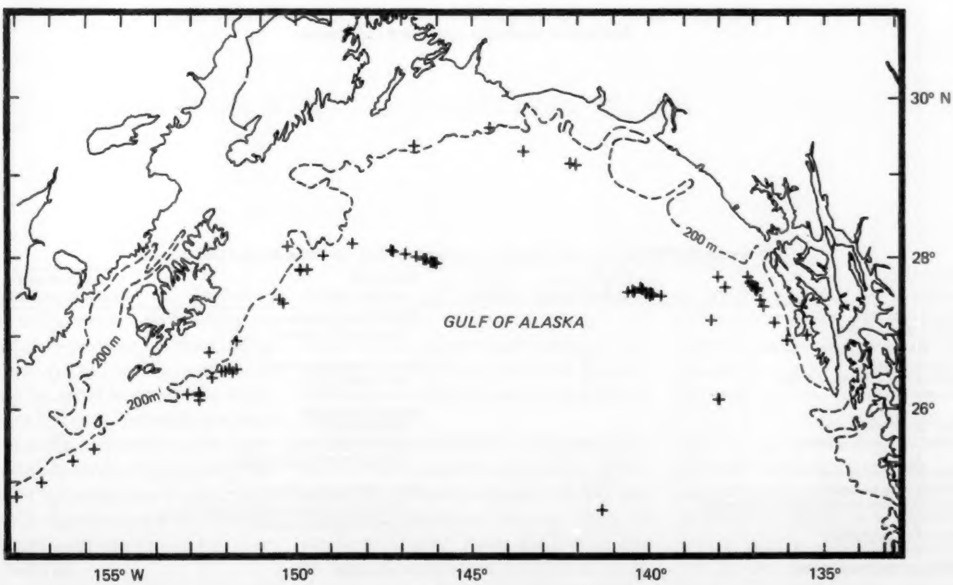


Figure 7.—Locations where northern fur seals were collected in the Gulf of Alaska whose stomachs contained Gonatidae.

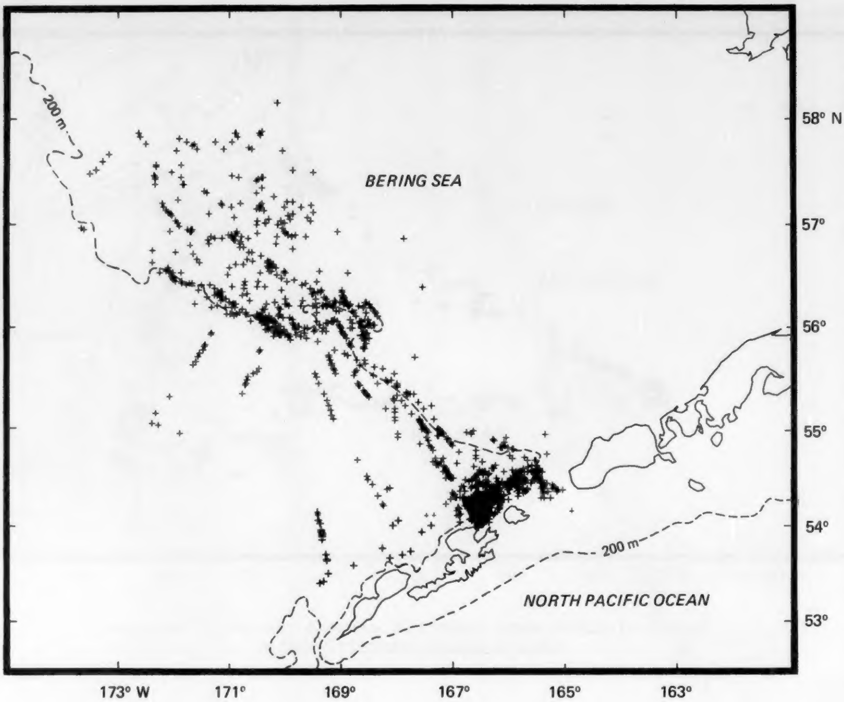


Figure 8.—Locations where northern fur seals were collected in the Bering Sea whose stomachs contained Gonatidae.

Table 2.—Squids identified from the stomachs of sperm whales from the Bering Sea and Gulf of Alaska[1,2].

Family and species name	Aleutian area and Bering Sea	Gulf of Alaska	Family and species name	Aleutian area and Bering Sea	Gulf of Alaska
Family Gonatidae			Family Chiroteuthidae		
Gonatopsis borealis	2	–	*Chiroteuthis veranyi*	2	–
Berryteuthis (Gonatus) magister	1,2	1			
Gonatus fabricii	2	–	Family Mastigoteuthidae		
Gonatus fabricii var separata	2	–	*Mastigoteuthis* sp.	1	–
Gonatopsis makko	1				
			Family Cranchidae		
Family Octopoteuthidae			*Taonius pavo*	1,2	–
Octopoteuthis longipetra	2	–	*Galiiteuthis armata*	1,2	–
			Cristalloteuthis behringiana	2	–
Family Onychoteuthidae					
Moroteuthis robustus	1,2	1	Family Ommastrephidae		
Onychoteuthis (banksii) borealijaponicus	2	–	*Todarodes (sloaneipacificus) pacificus*	2	–
			Ommastrephes bartramii	2	–
Family Histioteuthidae					
Stigmateuthis	1	–	Order Octopoda		
Meleagroteuthis separata	2	–	*Octopus* sp.	2	–
Family Architeuthidae					
Architeuthis japonica	2	–			

[1]1 = data from Okutani and Nemoto (1964).
[2]2 = data from Kodolov (1970).

Table 3.—Cephalopods identified in the stomach contents of northern fur seals, *Callorhinus ursinus*, collected during pelagic fur seal investigations, 1958-74.

Year	Location[1]	*Loligo opalescens*	*Abraliopsis* sp.	*Octopoteuthis* sp.	Other gonatids	*Gonatus* spp.	*Berryteuthis* spp.	*Gonatopsis borealis*	*Onychoteuthis borealijaponicus*	*Moroteuthis robusta*	*Chiroteuthis* sp.	Unident. squid
1958	CA	x	—	—	—	x	—	—	x	—	—	x
	OR	x	—	—	—	—	—	—	x	—	—	x
	WA	—	—	—	—	—	—	—	—	—	—	—
	AK (SE, GA, WA, BS)	—	—	—	—	—	—	—	—	—	—	—
1959	CA	x	—	—	—	x	—	—	x	—	—	x
	OR	x	—	—	—	x	—	—	x	—	—	x
	WA	x	—	—	—	x	—	—	x	—	—	x
1960	AK	—	—	—	x	x	x	x	—	—	—	—
1961	CA	x	x	—	x	—	—	x	x	—	—	x
	OR	x	—	—	x	—	—	—	—	—	—	x
	WA	x	—	—	x	—	—	x	x	—	—	x
	BC	x	—	—	x	—	x	—	—	—	—	x
1962	AK (WA, UP, BS)	—	—	—	x	x	x	x	—	—	—	x
1963	AK (BS)	—	—	—	x	x	x	x	—	—	—	—
1964	CA	x	—	—	x	x	—	—	x	—	—	x
	OR	x	—	—	x	x	—	—	x	—	—	x
	WA	x	—	—	x	x	x	x	—	—	—	x
	AK (BS)	—	—	—	x	x	x	x	—	—	—	—
1965	CA	x	x	—	x	x	x	x	x	x	x	x
	WA	x	—	—	x	x	—	—	—	—	—	x
1966	CA	x	x	—	x	x	—	—	x	x	—	x
1967	WA	x	—	—	x	x	—	—	x	—	—	—
1968	WA	x	—	—	x	x	x	—	x	—	x	x
	AK (GA, BS, WA)	—	—	—	x	x	x	x	—	—	—	x
1969	WA	x	x	—	x	x	—	—	x	—	—	x
1970	WA	x	x	—	x	x	x	x	x	x	x	x
1971	WA	x	x	—	x	x	—	x	x	—	x	x
1972	WA	x	x	x	x	x	x	x	x	x	x	x
1973	AK (BS)	—	—	—	x	x	x	x	—	—	—	x
1974	AK (BS)	—	—	—	x	x	x	x	—	—	—	x

[1]SE = southeastern Alaska, GA = Gulf of Alaska, WA = western Alaska, UP = Unimak Pass, BS = Bering Sea, CA = California, OR = Oregon, WA = Washington, AK = Alaska, BC = British Columbia.

collections were made off California from July to December, off Washington from July to November, in the Gulf of Alaska from August to February, or in the Bering Sea from November to April, times when few or no fur seals are present. Information is needed on the distribution and abundance of squids for given localities for the entire year to determine if potentially valuable squids are available in significant numbers to support commercial fisheries.

By combining data available on cephalopod occurrences in the stomachs of fur seals, other pinnipeds, small cetaceans, and sperm whales with those obtained from traditional methods of direct collecting and sampling, we can compile a useful base of information for cephalopod stock assessment and fishery development.

Based on frequency of occurrence in the stomach contents of marine mammals, the following squids probably are sufficiently abundant in some parts of the North Pacific Ocean and Bering Sea to support commercial fisheries: *L. opalescens,* presently fished off central and southern California, could probably support fisheries from northern California to British Columbia; *Onychoteuthis borealijaponicus* may also be sufficiently abundant in this area and seasonally into Alaskan waters. At least two (*Berryteuthis magister* and *Gonatopsis borealis*) of the 12 or more species of gonatid squids found in the area are large and probably abundant enough for commercial utilization from Washington north to the Bering Sea. Populations of several genera (*Symplectoteuthis, Dosidicus,* and *Ommastrephes*) within the family Ommastrephidae are probably abundant enough to support commercial fisheries from subtropical waters north

to southern California. One member of the genus *Ommastrephes, O. bartramii,* occurs north to the subtropical-subarctic boundary region and may be present further north seasonally in sufficient numbers to support a fishery.

Octopus spp. which are found on the continental shelf throughout the region form part of the catch in the bottom trawl fishery and are regularly taken by harbor seals, northern and California sea lions, several of the ice-inhabiting seals, and sperm whales.

Information that can be obtained from examinations of marine mammal stomach contents and used for developing commercial fisheries include: Identification of prey, date and general location where the marine mammals are captured, and the size, sex, and reproductive condition of prey. Clarke (1977) mentioned that marine mammals often are more efficient in capturing large squids than are nets; thus, information on size (maturity) of a species in a given location perhaps can best be obtained through the identification of stomach contents.

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International Awareness for Quality Seafoods: A Survey

CARMINE GORGA and LOUIS J. RONSIVALLI

Introduction

By the time that Columbus sailed in 1492, the Worshipful Company of Fishmongers of the City of London, "had been in existence for over 200 years" (Watkin, 1980). Its work involved keeping out the "foreigners" from south of the Thames and, with royal approval, fixing prices. "When prices are fixed," commented Watkin, "so must be the quality and, therefore, each of the victualling (food and drink) guilds had power to inspect and condemn."

"Mr. Ogvind Lie, of Frionor Norsk Frossenfish (sic), Oslo . . . quoted the following Norwegian quality programme *anno 1444*: 'Stockfish quality grading shall hereafter be mandatory . . . Each one who is doing otherwise . . . has lost the ownership of the stockfish in question, and this shall thereafter belong to the kingdom . . . And the grading men should have for their strive, one half fish for every hundred and twenty they have been grading'" (Phillips, 1980a).

Despite these ancestral auspicious beginnings, seafood quality control programs throughout the world have shown varying degrees of continuity and efficiency. This article is concerned with recent developments in the field which, as evidenced by the many trade publications and journals surveyed, have gradually led to the widespread realization that the lack of assured quality to consumers is the single most important impediment to the growth of seafood consumption and the growth of the seafood industry as a whole.

This article is divided into three sections. The first reports on countries that have earned a deserved reputation for their high quality seafoods. These countries have, in effect, set standards against which, in a world of intense international trade relations, other countries have to be measured. The second section reports on countries that have lately shown an increasing awareness for the need to improve the quality of their seafoods.

The last section gives a few concluding comments and recommendations. The emphasis is upon practical rather than technical and scientific (biological, chemical, or engineering) factors that have lately been taken into account to put in operation a quality program—a program that attempts to bring the highest possible quality of seafoods to consumers.

Carmine Gorga is the President of Polis-tics Inc., 87 Middle Street, Gloucester, MA 01930. Louis J. Ronsivalli is Director, Gloucester Laboratory, Northeast Fisheries Center, National Marine Fisheries Service, NOAA, Emerson Avenue, Gloucester, MA 01930. Mention of trade names or commercial firms in this article does not imply endorsement by the National Marine Fisheries Service, NOAA.

Countries With a Reputation for High Quality Seafoods

Some countries are recognized worldwide for their consistently high quality seafoods. Examples include Norway, Denmark, Poland, Iceland, and Japan. Here is a brief account of some of the literature indicating the strict quality control measures now in use in some of these countries.

Norway

A report (Alaska Fisherman, 1980) pointed out that, as a seafood producer, Norway has problems with too many boats in relation to existing stocks and overcapacity of shore processing plants. But one problem it does not have is quality. Fish to be filleted are promptly bled, gutted, washed, and carefully stored and unloaded. Vessels limit themselves to small hauls, and processing plants produce "top-quality fillets and second-quality products. A third category of the product (waste) is used for fox and mink farms."

Comments by the *Alaska Fisherman's Journal* (Anonymous, 1980a) are illuminating: "The regulations are extremely detailed down to such minutia as the incandescence and placement of lights over filleting tables." But, "The impact of these quality control standards is evident to anyone who spends even a day in Norway and eats three meals . . . the difference [is] between fish and fishy." The *Journal* then excerpted some of the official regulations: "The fish shall be frozen preferably before rigor mortis sets in or while it is still in rigor . . . . The freezing plant shall ensure that all large fish (tuna, porbeagle and skate) are chilled in ice to at least +4°C or colder at the warmest point before the freezing begins . . . . Packing and freezing shall be done in such a way that the goods are cooled to a temperature of −15°C or colder in the warmest point within 24 hours after they have been placed in the freezer." The administrative structure of Norway's quality control program is very

Prepackaged U.S. Grade A fish fillets just after packing in a shipping container at the plant where they were produced.

streamlined. It has delegated many functions to industrial control agencies (Lie, 1980).

Iceland

Wood (1978) stated that "The quality of fish landed is expected to be high, and by and large it is. The proximity of the grounds to the processing plant make spoilage through age almost impossible to attain. But attitudes at sea and on shore to quality ensure that handling techniques are of the highest order."

There is also a reverse side to this coin. While strict control measures are usually required to achieve high quality products, care must be exercised that overregulation does not interfere with productivity and efficiency. Iceland has run into this problem, but appears to be on its way to correcting excesses of regulation (Dagbjartsson, 1980).

Japan

For 30 days, "I became an interrogative picture-taking sponge that tried to absorb culture, business fact and fantasy for 14 hours a day" (Staples, 1980a). An article in two parts and a series of lectures distilled this experience. The theme of the visit, requested by the New England Fisheries Steering Committee and sponsored by Japanese concerns, was "How does Japan get its fish quality?" The answers—and the slides—came fast and furious. They are loud and clear.

Although the average trip length for the offshore fleet is 40 days, a system of "carrier boats" picks up the fresh catch every 3 days. Offshore trawlers are also endowed with a plate-freezer, ice-maker, and desalinator. Equipment and gear is up-to-date; crew accommodations are excellent and clean. Fish destined for the fresh market are packed onboard, "with an eye toward artistry," in styrofoam boxes to be used only once (Staples, 1980b). By 2:00 p.m., the auction market in Tokyo has cleared out and the entire facility "is scrubbed until spotless."

Staples was equally impressed by products and procedures in shore processing plants. As a result, the Japanese market is difficult to penetrate if the product is not of high quality (e.g., Smith, 1980), but is quite profitable once the quality standards are met (e.g., Anonymous, 1979a). The overall approach followed in Japan seems to be the following one: "In the upgrading of low-quality fish and fish materials, the seafood industry has much to learn from the meat processing industry" (Ayukawa, 1981).

Countries Recognizing the Need to Improve Seafood Quality

Of the larger seafood producing nations, the United States and Canada have recognized the need to improve their image in the international arena. Both countries, as well as others, have either demonstrated the benefits of assured quality or have made strong commitments to improved quality control. Literature on these efforts is surveyed here.

United States

Citing the work done by Consumer's Union over more than a decade which documented the existence of the low quality of fish available to the U.S. consumer, Ronsivalli et al. (1978) described the essential elements of a successful program established by the Northeast Fisheries Center's Gloucester Laboratory in conjunction with private industry. The authors listed the characteristics which fisheries products must exhibit to be classified as U.S. Grade A, and identified, among other contributing factors relating especially to filleting and packaging, the time/temperature integration as being essential to the preservation of quality in fresh fishery products up to the moment of consumption. The article also documented the wide acceptance accorded to this type of product by the processor, the retailer, and the consumer.

Retailers who implemented the quality assurance policy reported significant sales increases (Machiaverna, 1977; Zwiebach, 1978; Anonymous, 1980b). The additional cost involved in producing U.S. Grade A fresh fillets (about \$0.10/pound) was later found to be amply covered by the higher retail prices commanded by graded vs. ungraded fillets (Gorga et al., 1979). By early 1980, it was found that this program had grown exponentially to include 11 processors

and 1,100 supermarkets selling about 11,000,000 pounds of fresh fillets per year at a value of approximately $30,000,000 (Ronsivalli et al., 1981). The Gloucester laboratory staff considered the enormous potential of a program assuring the quality of U.S. frozen seafoods to the consumer (Nickerson and Ronsivalli, 1979), and has initiated a study of its economic feasibility.

Since the procedures recommended for this quality program had generally been expressed either piecemeal in various reports or verbally, a paper has lately been written on this topic (Ronsivalli, 1982). Its central thesis is that "The point at which the quality of a fish fillet really counts is when it is being consumed. At any other point, quality is important only as an indicator of what can be expected when the fillet is consumed." Therefore it recommends the maximum times and temperatures that either fresh or frozen fish and fish fillets ought to be held at each distribution element; it suggests a series of handling procedures to achieve the recommended time/temperature integration, and lists some of the alternatives that might be followed for fish that is kept for more than 2 days in the vessel hold and is not destined to be frozen.

By 1980, about 4 years after the economic and other advantages of assured quality had been demonstrated by NMFS technologists, the awareness of the need for "QUALITY - and its partner, quality controls" had become rather widespread in the United States (Donnell, 1980a). The Maine Department of Marine Resources and the Maine Development Foundation combined to develop a quality control program for adoption by the industry. The program ". . . is unique for Maine, and quite possibly the United States, in that it spells out a single, comprehensive system of quality controls which spans all levels of the groundfishery from the harvester to the final marketplace." (Anonymous, 1980c).

The Rhode Island Seafood Council also announced its intention to implement a quality program that would initially be paying participating vessels a premium price for fish to be processed and distributed under the U.S. Grade A label (Tarasevich, 1981). Thus quality came to be generally recognized as the key for opening up new markets for fisheries products, not only in the Midwest and in foreign countries, but "just a couple hours drive from the wharf," (Donnell, 1980a) and even in the local school lunch programs (Donnell, 1980b).

The idea of selling quality fish, in fact, can be implemented by any single-minded concern. Such is the case of the Stinson Canning Company, Rockland, Maine, the first reported business in that State to recognize the many advantages that can be derived from the use of plastic boxes on its fishing vessels (Day, 1981; Anonymous, 1981a). Such is the case of Jon Rowley of Seattle, Wash. (Fitzgerald, 1980), who guarantees that his fish is not older than 3 days, charges up to twice the going price, and his buyers reportedly cannot get enough of his fish. He buys everything fishermen catch and pays them about double the price on most species, but insists on the following standards: *"All fish must be caught on hook and line. No fish which comes over the rail dead will be sold as fresh fish. All fish will be bled immediately while still alive. All fish, with the exception of rockfish which are sold whole and ungutted, will be cleaned within two hours after bleeding. All fish must be iced immediately after cleaning and sorted by size and species into 100 liter totes. The totes are taken off the vessel no later than the next day and trucked to Seattle directly to buyers."*

But can a quality program be adapted from the local to a large scale and even the international market? Although necessary, this is not an easy step. The telegraphic style of a business communication (Anonymous, 1980d) gives a broad picture of what the U.S. fisheries industry needs to do in the field of foreign trade: "S.I.A.L. in Paris was again an eye-opener to North Americans. Quality of *Fish* and *Shellfish* products, packaging, and presentation by European countries and companies was in sharp contrast to *very poor* U.S.A. (first effort at S.I.A.L.) booth displays and *equally poor quality* of some *Seafood* products and packaging offerings by U.S.A. companies."

In confirmation of those difficulties, one can cite two articles appearing next to each other in a major newspaper. The

Prepackaged U.S. Grade A fish fillets in an open, refrigerated display case at one of the supermarkets that is selling the high-quality fish fillets.

first article (Mohl, 1980) reported on the proceedings of a seminar stressing that the United States runs a $2 billion trade deficit in seafood, that the potential for overseas sales is considerable, but that "poor quality standards and the lack of world-wide marketing" are problems to be overcome. The second article (Smith, 1980) reported that the demise of a long established seafood processor might have been averted, had it not been for "a Japanese company's refusal to accept $1 million of contracted fish because of poor quality. . . ."

The need for an official assessment of the quality of seafood products has ultimately been recognized at the highest levels of the U.S. government. At the beginning of 1981, it was widely reported that the General Accounting Office (GAO) had asked NMFS to conduct a survey "to document the extent that quality defects exist in U.S.-produced seafood products" (e.g., Anonymous, 1981b).

Canada

Set against "a slippage of quality when comparing the production of the 70's with the 60's" (Blackwood, 1980), the focus of attention in Canada has become the preparation of official standards published by the Department of Fisheries and Oceans in a booklet entitled "Quality Excellence in the 80's." The overall policy is that "All sectors of the industry must cooperate to ensure that the Canadian name on a product brings automatic recognition of top quality on the markets of the world" (Anonymous, 1980e).

The implementation of this policy has resulted from extensive consultations with all segments of the industry (Anonymous, 1979b; Hjul, 1980; Blackwood, 1980) and intensive studies (Johnson, 1980; Anonymous, 1980f, g, 1981c). This policy, also reported by Phillips (1980a), involves a detailed and scheduled program of: Vessel certification; quality protection on board; dockside grading; unloading, dockside handling and transportation to plants; improved quality control in processing plants; final product grade standards; and advice on handling and processing practices. The implementation of the policy was accompanied by anticipated increases in budgetary assistance (Surette, 1981).

This assistance has lately been realized in order to insure that, in the words of Romeo Le Blanc, Canada's fisheries minister, "Canadian fishery products are of consistently high quality to enable us to match and, hopefully, outdo our foreign competition in the world" (Anonymous, 1931d).

Official efforts to improve quality have been paralleled by private industry efforts. In 1980 National Sea Products Limited and B. H. Nickerson and Sons Limited announced the formation of a jointly owned research and development company, Fisheries Resource Development Limited (Anonymous, 1980h). The central area of involvement for this enterprise was planned to be quality improvement and product development. The importance of high quality has also been firmly supported by the Fisheries Council of Canada, whose chairman is on record stating that "It is my strong conviction that quality enhancement is an essential key to market growth at home and abroad" (McLean, 1980). The President of the Fisheries Association of Newfoundland and Labrador is also on record stating: "Quality enhancement is a key to the future of the industry, in both catching and processing, without a major effort on quality success in terms of the potential will not be achieved" (Wells, 1980).

England

In England the administrative structure of the official quality control program appears to be quite streamlined. Outside the City of London this responsibility is carried out by the Environmental Health Inspector (Sanitation), but in London it is still carried out by the Worshipful Company of Fishmongers (Watkin, 1980). The company is a private organization administered by a Chief Inspector and two assistants (Fishmeters). In addition to quality control, the company also performs relevant studies, is a funding source for other fisheries research organizations, and carries on an extensive training program. By virtue of a consistent quality control program, frozen fish has made inroads into Billingsgate "provided that fresh supplies are not available" (Watkins, 1980).

U.S.S.R.

Just as in Norway, Iceland, England, or Japan, it is the official policy in the U.S.S.R. to have fish of the highest possible quality. A. A. Ishkov, the Minister of Fisheries, is on record stating that the number one task for the fishermen today is "The quality of the product" (Ishkov, 1975).

Australia

An experience strikingly similar to that of the United States has taken place in Australia (Watson, 1979). The only difference is that the initiative was taken by a supermarket chain, G. J. Coles and Co. Ltd. The first paper outlining the program was delivered at the Fishexpo '76 in Melbourne and was "largely met with disbelief, criticism, scepticism and disinterest" (Watson, 1979). However, after tentative test marketing in a handful of stores of branded, prepacked, chilled (0°-2°C) fish supplied by an independent processor, "a network of production centres and distribution systems, covering most of Australia" have been established in little over two years, and six new processing and packing plants have been built (Watson, 1979).

The similarity extends to other factors: Promotion and advertising was very limited; in country or inland towns remote from sources of fish the demand was higher than average; prices could be relatively high, thus "supporting the view that quality and presentation are significant for shoppers, as long as price does not become unrealistic or uncompetitive with other protein foods such as meat and poultry." Problems to overcome also appear to be essentially the same as in the United States: The supermarket chain is still "often unable to acquire sufficient quantities of good quality Australian species"; all segments of the industry must still "resolve existing

problems of product identification and naming"; consumers are still "very suspicious about fish quality and freshness"; provided price is not excessive, "frozen fish can be marketed successfully" (Watson, 1979).

New Zealand

The adoption of the 200-mile zone legislation in New Zealand, as in other areas of the world, brought with it substantial investment in new vessels and processing plants, and consequently difficulties in marketing the increased catch (Anonymous, 1979a). A study was commissioned by the Department of Trade and Industry and it was found that even though Japan is already New Zealand's second largest market it still offers the best opportunity for expansion, because, "provided the quality is right, the market offers the best price, as well as being able to absorb large quantities." The study stressed that "the potential export earnings from relatively small volumes of high-value fish could equal those from large quantities of the offshore trawled species on which most attention is currently focused." And in any case, to reach the potential will "involve producing an acceptable product in terms of freshness, size grading and packaging; and the development of long-term [trade] relationships . . . ." In short, New Zealand concerns must supply "regular quantities of consistently high-quality fish" (Anonymous, 1979a).

FAO

At the third International Seafood Conference (1980) organized in Rome by the Food and Agriculture Organization (FAO) of the United Nations, three major points were raised which are relevant to this article (Phillips, 1980b). First, world exports of fisheries products have increased considerably in the decade of the '70's (from $3,392,000,000 to $11,170,000,000), with the share of developing increasing at one-third higher rate than that of developed countries (from $1,000,000,000 to $3,800,000,000). Second, there exist problems faced especially by developing countries related to product quality, prices, and insufficient and/or costly shipping facilities. Third, as stressed by Murray Hillman, a marketing expert, fish must be made "a chic experience" not just food. This point has been recently confirmed and stressed by an in-depth survey of consumer reactions (Anonymous, 1981e).

Discussion

The points raised at the FAO conference (Phillips, 1980b) might serve as the backbone of a few comments and recommendations. First, the recent growth pattern of the fishing industry represents the opportunity to be exploited. It might be worthwhile to reinforce this point with one general set of statistics: "During the Korean War, the world-wide harvest of fish was 20 million tons. By 1970 it topped 70 million and is expected to surpass 90 million tons by 1983" (Noble, 1981).

Second, the many problems faced by the industry, some of which can be inferred from the above, represent the obstacles to overcome. Third, making fish "a chic experience" (i.e., not only producing high quality seafoods, but also making them look like high quality products) appears to be the method through which obstacles can be overcome and the potential reached by the seafood industry worldwide.

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Kurt A. Wilhelm is with the Gloucester Laboratory, Northeast Fisheries Center, National Marine Fisheries Service, NOAA, Emerson Avenue, Gloucester, MA 01930.

Extended Fresh Storage of Fishery Products With Modified Atmospheres: A Survey

KURT A. WILHELM

ABSTRACT—Alterations in the pressure or gaseous composition of storage conditions can be applied to reduce bacterial and oxidative spoilage of fresh fishery products. These methods, vacuum packaging, hypobaric storage, hyperbaric storage, and the use of such gases as carbon dioxide and ozone, are reviewed in this paper. While oxygen depletion is effective in retarding the growth of the typical spoilage bacteria, there is a possibility that if the product is temperature abused, it may become toxic (i.e., from Clostridium botulinum*) before spoilage is apparent. Under strict temperature control, atmospheric modification can be shown to extend the shelf life of fresh fish. CO_2-enriched atmospheres have thus far received the greatest commercial usage for the bulk shipment of fresh fish.*

Introduction

Fish is one of the most perishable of foods. In unfrozen seafood, bacterial activity is responsible for the most pronounced offensive changes in odor and flavor. Lipid oxidation in fish with a high fat content results in rancidity. Fish such as herring, *Clupea* spp., and trout, *Salmo* spp., can become rancid before microbial spoilage is evident (Hansen, 1963). Endogenous proteolytic enzymes adversely affect the texture of fish, but their activity is relatively insignificant during commercial storage periods (Liston, 1965).

Refrigeration has for many years been successfully used to retard spoilage of fresh fish. However, at 0°C the shelf life of a lean fish such as Atlantic cod, *Gadus morhua*, is about 14 days and at 5°C the shelf life is only about 6 days (Ronsivalli and Charm, 1975). After a short storage period the product must be discarded. From an economic viewpoint, the ability to preserve the quality and nutritional value of nonfrozen fish for extended periods of time could be greatly rewarding in terms of reduced waste, increased value of the product, and increased sales (Gorga et al., 1979).

As a supplement to refrigeration, variations in the pressure and gaseous composition of storage conditions have been proposed as methods of extending the fresh storage life of fishery products. This paper reviews those methods.

In the literature, the term "modified atmosphere" is usually limited to those storage conditions where the atmospheric gas concentrations are altered before storage. In "controlled atmosphere" systems, the selected atmospheric concentrations of gases are actively maintained throughout storage. However, in a general sense, atmospheric modification may include any deviation from normal atmospheric pressure or composition. The pressure is reduced under hypobaric storage and increased under hyperbaric storage conditions. Modifications of atmospheric composition include storage under levels of carbon dioxide, oxygen, nitrogen, and other gases which differ from normal air. If, for example, carbon dioxide is added to the storage container, the environment is referred to as "CO_2-enriched." Atmospheric modification may be within an individual package or within a bulk container.

Vacuum Packaging

Vacuum packaging represents a static form of hypobaric storage which is widely applied in the food industry due to its effectiveness in reducing oxidative reactions in the product at relatively low cost. This technique is applied to frozen and heat-treated products. Although it would also be effective in reducing the growth of the typical spoilage bacteria, its use is not recommended for refrigerated fish. Until proven otherwise, it must be assumed that the conditions exist for the growth of such toxin producing organisms as *Clostridium botulinum*. Botulism can occur in unsterilized, nonacid products held in anaerobic conditions at temperatures above 3°C.

There are, however, several reasons why vacuum packed fish may not become toxic to a consumer. *Clostridium botulinum* requires a reduced substrate on which to grow. Eliminating oxygen from the environment can create this condition, but Johannsen (1965) notes that there are many other naturally available oxidizing agents which can counteract the effect of low oxygen levels. Secondly, competing microorganisms may have an inhibitory effect on clostridia. Vacuum packaging favors the growth of lactobacilli. Johannsen (1965) mentions that the lactobacilli form peroxides and acids which inhibit the growth and toxin formation of *C. botulinum*. Also, the fish flesh may contain antimicrobial agents. Zak (1970) has found that haddock, *Melanogrammus aeglefinus*, contains an antimicrobial polypeptide which inhibits the growth of *C. botulinum*. It may also be present in other lean fish species.

A further factor is the initial number of bacteria present. A small bacterial population is more readily inhibited than a large population. It is also possible that the product will not be stored at temperatures above 3°C. Finally, Licciardello et al. (1967a) have reported that even if botulinum toxin is formed, normal cooking procedures will inactivate it.

Johannsen (1965) summarizes these effects by asserting that it is the condition of the product itself and not vacuum packaging per se which determines whether or not botulinum toxin will form.

It should be noted that the inhibitory effects may not be sufficient to prevent toxin formation and that the effectiveness of vacuum packaging in retarding growth of the typical spoilage bacteria may lead to a product which has become toxic before spoilage is apparent. Both vacuum- and nonvacuum-packaged smoked fish have been implicated with botulism outbreaks. Temperature abuse of the product was indicated in these cases. (Cann et al., 1965).

Huss (1972) compared the quality of plaice, *Pleuronectes platessa,* and haddock held in ice without packaging with fish packed in polyethylene without vacuum, vacuum-sealed polyethylene, and vacuum-sealed polyamide (Nylon 11[1]) pouches held in ice. During the 20-day storage period the plaice packed in evacuated bags had the lowest oxygen content, the lowest bacterial count, and the highest quality score. Compared to the unwrapped plaice, a 6-day extension of shelf life was obtained. Unexpectedly, the haddock did not show an extension of shelf life for the evacuated polyamide pouch. This result was not explained. Packaging without vacuum was judged as not advantageous for either plaice or haddock.

Licciardello et al. (1967b) identified the spoilage bacteria of irradiated (150 krd) and nonirradiated, vacuum-packed (74 mm Hg) haddock fillets after storage at 2°C in metal containers. With the nonirradiated fillets, the spoilage bacteria after 13 days storage was predominantly proteolytic pseudomonads. At that time the fillets had only a slight fishy odor, but 6 days later the odor became definitely stronger, indicating the breakdown of trimethylamine oxide (TMAO) to trimethylamine (TMA). With the irradiated fillets the spoilage bacteria were chiefly lactobacilli. The odor of the fillets at 48 days storage was slightly fishy. Air-packed control fillets were putrid within 13 days. Spoilage of vacuum-packed petrale sole, *Eopsetta jordani,* fillets by pseudomonads has also been reported by Pelroy and Eklund (1966).

Hansen (1972) found that Atlantic herring, *Clupea harengus,* and trout, *Salmo irideus,* stored directly in ice became rancid in 6 days. Fish stored in evacuated polyamide bags did not become rancid during 20 days of storage, but they did develop an objectionable odor and flavor due to bacterial activity. Jorgensen and Hansen (1966) reported that by irradiating (50, 100, and 200 krd) herring and trout before vacuum packaging, the storage life could be extended to 4 weeks.

Use of the bacteriostat ethylenediaminetetraacetic acid (EDTA) with vacuum-packed petrale sole and ocean perch, *Sebastes alutus,* fillets was investigated by Pelroy and Seman (1969). Nonvacuum-packaged ocean perch spoiled in 5 days, and vacuum-packaged fillets spoiled in 6 days due to TMA production by pseudomonads. Application of disodium EDTA resulted in a 9-day extension of shelf life for the vacuum-packaged fillets. Vacuum-packaged petrale sole fillets spoiled after 7 days. Treatment with EDTA extended the shelf life at least 2 days. At that time the predominant flora consisted of coliforms and lactic acid bacteria. Air-packaged petrale sole fillets treated with EDTA had a shelf life of 6 days.

Vacuum packaging appears to have a moderate effect on the spoilage rate. High initial bacterial loads and insufficient vacuum contribute to its lack of effectiveness. In many of the studies the amount of vacuum is not reported, indicating a possible lack of pressure control. Reduction of the bacterial population with supplemental treatment further extends the shelf life of fish products.

Vacuum packaging of individual products can present a problem to the retailer in that although the product may appear marketable, all of the volatiles from decomposition are sealed within the package, and the product may actually have spoiled. Also, there is no clear evidence at this time that if the product is temperature abused, i.e., held at temperatures above 3°C, it will not become toxic.

Hypobaric Storage

The term "hypobaric storage" is usually applied to a dynamic low pressure system. This type of storage has recently been applied commercially for the preservation of fruits, flowers, and vegetables (Burg, 1976). In vacuum packaging, the container is evacuated and sealed. The practice in hypobaric storage is to use a rigid, temperature-controlled container under continuous evacuation. Because this treatment also removes moisture from the product, the container is continuously resupplied with water vapor. This dynamic evacuation accelerates the escape of such volatiles as ammonia and TMA from the product. The pressure in the chamber is maintained to within 2 mm Hg (Jamieson, 1980). The oxygen content is therefore regulated to 0.05 percent of the desired value.

As noted previously, the oxygen content is a critical factor in spoilage due to bacteria and rancidity. The effective oxygen content is related to pressure. A reduction in pressure from normal atmospheric pressure (760 mm Hg) containing 21 percent oxygen to one-tenth normal results in an effective oxygen content of 2.1 percent. The total pressure equals the sum of the partial pressures of the individual gases including water vapor. The partial pressure of water vapor is a function of temperature and water availability. Under evacuation, the water in the product is vaporized to maintain the partial pressure of the water vapor in the chamber. At 0°C the partial pressure due to water vapor is 4.6 mm Hg. So at low pressures a greater proportion of the total pressure is due to water vapor and the other gases are accordingly further reduced. Thus, the oxygen content is controlled.

Haard et al. (1979) investigated the use of hypobaric storage with Atlantic herring, *Clupea harengus,* and Atlantic cod held at 2°-4°C. Eviscerated cod held at normal pressure either in air or 0.2 percent oxygen were considered unacceptable after 6 days of storage. Cod held hypobarically at 13.7 mm Hg remained acceptable in appearance, odor, and microbiological counts during

[1]Mention of trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

13 days of storage. Eviscerated herring stored under normal pressure were judged unacceptable after 8 days storage, while those held at 20 mm Hg remained acceptable for 16 days. Hypobaric storage of whole herring did not delay deterioration due to endogenous proteolytic enzymes. Bellyburn was more frequent and much more severe in herring held at 20 mm Hg than in those stored at normal atmosphere.

Varga et al. (1980) reported that the storage life of cod; mackerel, *Scomber scombrus*; and herring fillets could be extended when stored under a pressure of 10 mm Hg. Treatment with EDTA further extended the storage life of the cod fillets. Mermelstein (1979) noted that the storage life of shrimp and freshwater prawn can also be doubled when stored at 10 mm Hg, $-1°C$, and a relative humidity of 95 percent.

Since refrigeration is part of the bulk storage system, as long as the equipment is operating properly the product is considered to be safe. Hypobaric storage appears more effective than vacuum packaging in prolonging the shelf life of fishery products, but its commercial feasibility has yet to be demonstrated.

Hyperbaric Storage

Hyperbaric storage refers to the use of high pressure systems. High pressure can stop microbial growth and reduce enzymatic activity. Charm et al. (1977) reported that at high pressure, the refrigerated storage life of Atlantic cod was greatly extended as determined by bacterial counts and sensory evaluation. After 30 days, fish held in a nonfrozen state at $-3°C$ and 238 atmospheres (1.8×10^4 mm Hg) were not significantly different from frozen controls held at atmospheric pressure and $-25°C$.

Because of the technical difficulties in building a commercially feasible high pressure storage unit, this preservation method has not been pursued.

CO_2-Enriched Atmospheric Storage

Of the methods for modification of atmospheric composition, the use of carbon dioxide has been investigated the most thoroughly. Research on the effect of CO_2 on the storage life of fish began in the 1930's. Killeffer (1930) briefly noted that fish stored in 100 percent CO_2 kept fresh from two to three times longer than controls in air at the same temperature. Coyne (1933) followed up on his preliminary studies (Coyne, 1932), which showed the growth of the spoilage bacteria *Achromobacter, Flavobacterium, Pseudomonas, Micrococcus,* and *Bacillus* could be effectively inhibited with high concentrations of CO_2. He reported that cod; lemon sole, *Microstomus kitt*; European plaice, *Pleuronectes platessa*; and whiting, *Merlangius merlangus,* could be kept at 0°C twice as long in a CO_2 atmosphere than in air. Optimal results were reported for CO_2 concentrations of 40-60 percent. At 10°C, 100 percent CO_2 was found to be the most effective. Whole fish and fillets were judged on the basis of appearance, odor, and texture. Stansby and Griffiths (1935) reported that the iced storage life of haddock could be doubled with the use of CO_2.

Recent studies (Banks et al., 1980; Brown et al., 1980) on vermilion rockfish, *Sebastes miniatus*; coho salmon, *Oncorhynchus kisutch*; Gulf trout, *Cynoscion nebulosus*; and croaker, *Micropogon undulatus,* have shown that while CO_2 is effective in inhibiting the growth of gram-negative bacteria (i.e., *Pseudomonas*) which produce trimethylamine and ammonia, growth of gram-negative bacteria such as *Lactobacillus* is stimulated. These bacteria produce acid, causing souring of fish during storage.

Pretreatment before storage in carbon dioxide has also been investigated to further improve the shelf life of fishery products. Mitsuda et al. (1980) noted an improvement in texture and color when fillets of *Seriola aurevittata* were dipped in 5 percent NaCl before gas storage. A propionic acid dip with either EDTA or ascorbic acid is reported to double the shelf life of sprat compared with CO_2 used alone (Windsor and Thoma, 1974). Fey (1980) reported that a combination of 1 percent potassium sorbate ice and modified atmospheres containing 60 percent CO_2 resulted in a shelf life of at least 4 weeks for red hake, *Urophycis chuss,* and 3½ weeks for chinook salmon, *Oncorhynchus tshawytscha.*

For voyages of up to 4 days, refrigerated seawater and chilled seawater holding tanks offer advantages in the quality and handling of fish aboard fishing vessels (Peters et al., 1965; Hulme and Baker, 1977). Further research has demonstrated that CO_2 bubbled through the brine reduced the bacteriological load and improved the shelf life of pink shrimp, *Pandalus borealis* (Bullard and Collins, 1978; Barnett et al., 1978); black rockfish, *Sebastes melanops* (Collins et al., 1980); chum salmon, *Oncorhynchus keta* (Barnett et al., 1971); silver hake, *Merluccius bilinearis* (Hiltz et al., 1976); and ocean perch, *Sebastes marinus* (Longard and Regier, 1974). There are many technological difficulties in using CO_2 with refrigerated seawater. These problems are due to the corrosive nature of CO_2, and are discussed by Nelson and Barnett (1971).

Carbon dioxide-enriched atmospheres are currently in use for the bulk shipment of Pacific salmon, *Oncorhynchus* spp. (Bell, 1980; Veranth and Robe, 1979). It has been shown that the shelf life of fresh fish can be doubled with CO_2. However, in view of the lack of toxicological studies to determine the botulism potential, the use of CO_2 in retail packages is discouraged.

Other Gases

Other inhibitory gaseous mixtures have also been studied for use in food preservation. Coyne (1932) showed that even at levels approaching 100 percent, nitrogen had no inhibitory effect on the typical spoilage bacteria. Ozone was found to have a preservative effect on fish (Haraguchi et al., 1969), and ammonia was reported to effectively preserve fish for 2 months at ambient temperatures (Subrahmanyan et al., 1965). Although the fish became soft, it was reported suitable for fish flour. Ethylene oxide, nitrous oxide, and other bactericidal or bacteriostatic gases have been investigated, but they are generally not considered practical for the preservation of fresh fish because of their inherently toxic properties.

Summary

The storage life of fishery products can be extended with modifications of

the storage pressure and atmospheric composition. For bulk shipment of fishery products, the use of CO_2 has been accepted in commercial practice for its effectiveness in retarding spoilage at a reasonable cost. But there remains the unresolved threat of the potential for botulism that is theoretically associated with packaging under low partial pressures of oxygen. Until safety from botulism can be demonstrated, the use of low oxygen storage conditions cannot be recommended for retail packages. Above all, for prolonged fresh storage, strict temperature control is necessary under any atmospheric condition in storage to ensure quality and safety.

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U.S. Albacore Landings Seen Highest in 3 Years

The U.S. albacore fishery was significantly better in 1981 than during the previous two seasons. As of mid-October U.S. landings (including those from Midway) were estimated to be about 14,000 metric tons (t) and there was a possibility that the landings for 1981 would exceed 15,000 t. The total U.S. landings (including those from Midway) for 1980 were about 9,000 t and for 1979 about 7,300 t.

By mid-October, most of the pole-and-line boats were still reported to be fishing in an area off San Francisco to Fort Bragg, Calif. Pole-and-line fishermen were targeting on a large body of large albacore, ranging between 20 and 60 pounds (9.1 and 27.3 kg). There was considerable natural food in the area and the fish were often difficult to catch. Poor weather conditions also tended to hamper the fishing effort. Nevertheless, fishermen continued to operate on the body of fish with modest success and with hope that the fish would "go wide-open on the bite." During the second week and part of the third week of October, some of the pole-and-line boats worked 8-30 miles off Fort Bragg. While information on the number of fish caught was scarce, it was reported the fish were averaging 30-35 pounds (13.6-18.9 kg).

Jigboats operated mainly between Monterey, Calif., and Cape Mendocino during the first half of October. Vessels were scattered between 150-200 miles off the coast and worked with limited success when birds and albacore were sighted; otherwise catches were poor. The average jigboat scores were 10-30 fish/day/boat with top catches of generally <150 fish per day. The size of the fish ranged from 6 to 50 pounds (2.7 to 22.7 kg) and averaged about 12-16 pounds (5.5-7.3 kg). Jigboats had been generally unsuccessful at getting fish to bite in the area off Fort Bragg to San Francisco where the baitboats were operating. Because of small catches and increasing frequency of rough seas, many of the jigboats had returned to their home ports and tied up for the season.

Phosphate Treatment and Freezing of Pacific Cod

During August 1981, scientists from the Utilization Research Division of the NMFS Northwest and Alaska Fisheries Center processed Pacific cod samples aboard the RV *Chapman* operating near Kodiak, Alaska. The purpose of the experiments initiated aboard the vessel is to study the effects of various treatments, including pre- and post-rigor freezing, on quality and quality changes in frozen cod.

Laboratory evaluation of one group of samples treated with phosphates has begun. Pre-rigor and post-rigor, skin-on fillets dipped 30 seconds in a solution of 4 percent sodium tripolyphosphate, 2 percent sodium hexametaphosphate, and 2 percent sodium chloride prior to freezing are being compared to untreated fillets. At the laboratory, the fish is thawed, skinned, trimmed, and refrozen. Prior to freezing, the representative samples were evaluated for physical and sensory changes.

In general, the samples were found to be of good quality. However, it was observed that both the treated and untreated pre-rigor cod samples were considerably discolored (moderate to severe) because of the presence of blood in the muscle tissue. This phenomenon was not observed in the flesh of the post-rigor cod samples which possessed white flesh normally associated with quality cod products. Slight to moderate gaping was observed in both the pre- and post-rigor processed fillets. After deglazing the fillets, free thaw drip analysis was made. Results showed that both pre- and post-rigor treated cod fillets averaged 26 percent less weight loss (as free thaw drip) than their corresponding controls. However, the treated post-rigor fillets lost 40 percent less free drip than the pre-rigor treated cod fillets. Free thaw drip for the pre-rigor, chemically treated cod samples averaged 5.9 percent and 8.4 percent for the controls. Free thaw drip loss for the treated, post-rigor samples averaged 3.5 percent and 6.1 percent for the untreated control.

Fillet yield (as a result of skinning and trimming) from the deglazed, post-rigor fillet samples that were chemically treated averaged 78 percent, whereas their corresponding controls yielded 69.5 percent. The post-rigor fillets yielded 74 percent edible product for the treated cod fillets and 66.7 percent for the untreated control samples. Similar studies are being made on headed and gutted cod blocks.

Measuring Phenol Content of Smoked Whitefish

One of the oldest methods of food preservation has been smoking of food (primarily meat or fish) by hanging it over a fire or in a room where the fire was maintained. In recent years, liquid smoke preparations manufactured from certain varieties of wood pyrolysates have been successfully used as a substitute for the traditional smoking in a kiln. Liquid smoke has the advantage of ease of application, speed, and uniformity of product, and it may be applied in a variety of ways, such as injection, spraying, or dipping.

Microbiological studies by Mel Eklund's group at the Northwest and Alaska Fisheries Center's Utilization Research Division have shown that liquid smoke plays a very important role in the inhibition of growth and toxin production by *Clostridium botulinum* types A and E in hot-processed whitefish steaks. The degree of inhibition and storage life of the smoked product depends upon factors such as the concentration of smoke and salt and the storage temperature. A method to determine the con-

centration of smoke in the finished product was considered necessary.

The chemical composition of the liquid smoke is known to be very complex, consisting mainly of acids, terpenes, phenols, carbonyls, and polynuclear aromatic hydrocarbons. The phenols (over 40 compounds have been identified so far) have been found to contribute significantly to the desirable odors and flavors of the smoked foods. They seemed like a good choice for quantitation, even though a review of the literature showed that difficulties still exist in obtaining quantitative recoveries of phenols from smoked foods, and methods of isolating the phenolic fractions from foods are either very time-consuming or have poor recoveries.

Studies are currently in progress to develop a rapid and reproducible method for extracting and measuring phenols from smoked fish. In extracting the phenols from the fish muscle, acetronitrile was passed over a sample of homogenized tissue that was packed in a liquid chromatography column. An aliquot of the extract was then used for analysis of the phenols by a colorimetric method.

The above method was used to measure the phenol content of smoked whitefish. Two lots (1 and 2) were brined for 2 days in 3.2 percent salt solution prior to dipping in a smoke solution for 2 and 60 seconds. Another lot (3) was similarly held 2 days in a brine solution that also contained 3 ounces of smoke per gallon of brine. All 3 lots were then held an additional day at 38°F for equilibration. Results of the analyses showed phenol concentrations of 5.40, 5.67, and 8.58 mg/100 g of fish for lots 1, 2, and 3, respectively. The analyses were in duplicate and agreement among the replicates was excellent. The data indicate that a variation of about 1 minute in dip time had only a very slight effect upon the amount of phenol found in the fish tissue. An extended exposure of the fish flesh to a dilute smoke solution (3 ounces of smoked solution/gallon) in conjunction with salt resulted in higher phenol levels. Although the overall procedure still needs to be carefully tested on a series of samples before final acceptance, the outlook is very promising.

Fuad M. Teeny

Improving the Keeping Quality of Frozen Pollock Surimi

The technical and economic feasibility of a domestic fishery for the walleye (Alaska) pollock, *Theragra chalcogramma,* depends greatly on two major factors: 1) Utilizing the harvest for food as frozen fillets, blocks, and minced fish products including surimi; and 2) assurance of good quality and acceptability of the frozen products during a market period of 1 year. Current utilization research in Seattle and Kodiak laboratories of the National Marine Fisheries Service includes studies of seasonal and quality variations in the landed pollock, keeping quality of iced or refrigerated fresh fish, and methods of processing for freezing and storage in various intermediate forms.

Surimi is an important frozen minced fish product developed by the Japanese for use in kamaboko and a variety of prepared products. Japanese import regulations specify that surimi is prepared from suitable fresh fish (such as pollock) with washing (water leaching) of the minced flesh and addition of sugar, sorbitol, sodium tripolyphosphate, and emulsifying agent followed by blending, packaging, freezing, and storage.

In this study, high quality frozen whole pollock were prepared at Akutan, Alaska, in February 1980 and thawed at the Seattle laboratory 2 months later for the surimi preparation. Fresh pollock of comparable quality were not available for use as a control lot. The study variables included the effect of washing the minced flesh, the use of the additives (sugar, salt, and tripolyphosphate), and the effect of storage at 0°F (−18°C) and −20°F (−29°C).

The study was initiated by visiting scientist Javier Borderias in 1980, and the sample analyses were completed by George Kudo of the Northwest and Alaska Fisheries Center's Utilization Research Division following Javier's return in September 1980 to the Institute of Refrigeration, University of Madrid, Spain. Detailed evaluation of the physical/chemical examination and analysis of the samples from the 1-year study has not been completed; however, the following preliminary observations are apparent from the quality and chemical changes of the 12-month samples.

1) Effect of not washing. Frozen unwashed minced pollock with no additives and stored at 0°F (−18°C) was judged unacceptable in quality after 12 months of storage. Samples had high shear values, low elasticity, and high dimethylamine values.

2) Effect of washing. Minced pollock that was given a single or double wash, then dewatered, frozen, and stored at −20°F had acceptable quality and texture after 12 months of storage. Samples stored at 0°F were of borderline acceptability and showed poorer texture and elasticity values than those stored at −20°F.

3) Effect of additives—sugar, tripolyphosphate, and salt. Addition of sugar and tripolyphosphate did not improve the quality of frozen unwashed minced pollock (see item 1) after 12 months of storage at 0°F. Addition of sugar and tripolyphosphate improved the acceptability and texture of frozen washed minced pollock (see item 2) after 12 months of storage at either 0°F or −20°F. Addition of salt to the additives accelerated the adverse texture changes in pollock surimi and, after 12 months at 0°F, the samples showed poor texture and were nonelastic.

4) Effect of storage temperature 0°F (−18°C) and −20°F (−29°C). Pollock surimi (frozen washed minced flesh with the additives sugar and tripolyphosphate) was of acceptable quality and texture after 12 months of storage at −20°F. Similar samples stored at 0°F had inferior texture but were otherwise acceptable after 12 months of storage. Frozen unwashed minced pollock stored at −20°F for 12 months had poor quality and texture (nonelastic) but was still significantly superior to samples stored at 0°F.

The results of the study after further evaluation will be prepared for publication; preliminary recommendations will be prepared for industry application and further study.

John Dassow

The Polish Fishing Industry

Polish fishermen caught about 700,00 metric tons (t) in 1980. The Polish catch has been as high as 800,000 t, but has declined as a result of the 200-mile extensions by coastal countries.

The NMFS Division of Foreign Fisheries Analysis forsees no large increase in future Polish fisheries catch and any increase in per capita consumption will probably have to come from imports. Consumption of fishery products is now 7 kg per capita; consumption by 1985 is planned at 12 kg, but Polish officials believe that this figure will not be reached until at least 1990. The Government has been trying to increase per capita fisheries consumption for years, but Polish consumers have resisted, preferring freshwater fish (i.e., carp and trout) to unfamiliar marine species.

Poland has one of the larger fleets fishing in U.S. waters. Fish plays an important role in the Polish diet as a supplementary source of protein and as a source of hard currency. One of the directors of Rybex[1] stated that because of the poor state of Polish agriculture, it will be cheaper for Poland to obtain protein by fishing rather than by increasing supplies of meat for at least the next 15 years, even though labor and especially fuel costs will continue to rise.

Poland hopes to increase fish supplies for the domestic market during the next decade and beyond. Consumption of fish is now 7 kg per capita. The planned consumption by 1985 is 12 kg per capita but officials of the Central Board stated that this figure will probably not be reached at least until 1990. The government has been trying to increase per capita fish consumption for years. The problem is that Poles prefer such freshwater fish as carp and trout over unknown Pacific ocean and Antarctic species. A much more intensive public relations and educational program will have to be conducted before per capita consumption significantly increases.

Total annual catch in the past has been as high as 800,000 t but the estimate of the 1980 catch was closer to 700,000. No large increase in the annual catch is foreseen and any increase in per capita consumption will have to come from imports. Present domestic consumption of processed fish is about 240,000 t. An additional 40,000 t are exported.

In 1981, 418,000 t of herring, 227,000 t of cod and 60,000 t of sprats were permitted to be caught in the Baltic. Poland's allocations were 80,000 t of herring, 60,000 t of cod, and 13,000 t of sprats.

Poland's annual Baltic catch is about 200,000 t, 25-30 percent of the total annual Polish catch. Of this amount, about 29,000 t, 15 percent of the total annual catch, is caught by private fishermen. These people own their own boats and can hire help. They can sell privately or to the government-owned Centrala Rybna fish stores.

Centrala Rybna must purchase the fish if a fisherman wants to sell to the government. It is hard for individuals to sell privately as the government retail price for fish is heavily subsidized and has not been increased in 20 years. For example, 1 kg of cod fillet sells for 20 zloties (about 65 cents), less than half of its actual cost. Private sales of smoked or fried fish are usually made to tourists during the summer. An additional 43,000 t, 20 percent of the total annual catch, is caught by cooperatives whose boats are jointly owned. Approximately one-third of the total Baltic annual catch, therefore, is made by non-state boats.

The number of vessels in the Baltic fleet exceeds needs by about 25 percent, however, there is a shortage of properly equipped boats. State-built vessels are reportedly fitted with too much and too expensive navigational equipment for the Baltic fleet. These ships are more appropriately equipped for deep-sea fishing. There is also a shortage of processing equipment such as ice factories and cold storage facilities. The shortages are felt most severely in early spring during the cod season.

There is also a shortage of deep-sea vessels. When the 200-mile limit was put into effect, Polish fishing companies "temporarily" halted orders for new ships. They wanted to wait to determine what would be the best suitable vessel(s) as their chief future fishing activity was not known. It still is not known and the fleet is gradually growing older and smaller.

There are now about 300 boats in the Baltic fleet (excluding those less than 30 feet long) and about 130 deep-sea vessels. Morocco has closed its waters to Polish fishing vessels and the Polish-Senegalese joint venture ended in late 1980 when Senegal refused to renew the agreement.

The Poles presently have three joint ventures with Peru but feel unsure about future Peruvian cooperation. A joint

[1]Rybex is the foreign trade enterprise of the Polish Central Fisheries Board.

venture agreement has been signed with New Zealand and the Poles will soon start fishing there. But the ships formerly fishing off Africa are not suitable for New Zealand waters. Poland will have an excess of coastal fishing vessels if new cooperative ventures are not established. As a result, the U.S. market and fishing allocations are becoming very essential to Poland.

Poland's chief fish imports are fresh and salted herring, carp at Christmas, and mackerel. The biggest problem is money for imports. Money for imports is allocated by the Ministry of Agriculture and the Ministry of Food Supplies. Until 1980, there had been sufficient funds available. Starting in 1980 and continuing into 1981 (and likely in the future as well), insufficient monies were available to complete requisite purchases. This has caused an inability to buy fish when the price is low and results in an even greater foreign currency drain as higher prices must be paid for smaller amounts of fish.

Carp, the sine qua non of the Polish Christmas Eve dinner, is in short supply and is usually only available at Christmas. 12-13,000 t were needed for 1980 but Poland only produced 5,500 t and only planned on importing 3,500 t (which had to be paid for in hard currency). Two 1 kg carp are considered necessary for a family of four.

In 1980 there were shortages of carp in southern Poland and in small villages. Carp is sold live starting about 10 days before Christmas and a separate retail apparatus must be set up for this short period of time. Carp is sold whole, sometimes gutted or headless, but fillets are not suitable. In recent years, some frozen carp has been sold because it could be purchased abroad at a lower price.

The prospect of U.S. carp sales to Poland does not look promising. Polish carp has no or few scales and the flesh is white. U.S. carp is called wild carp (sazan) instead of carp (kar). It is fully scaled, bonier, has darker flesh and a different taste.

Poland in the past has exported fish fillets to other European countries. The Poles are now being underpriced by large sales of cheap fish fillets from Argentina. Moreover, Polish fishermen have recently won a 15 percent wage increase. One Polish official expressed the opinion that subsidies for the price of fish should be shifted to salaries so that there can be higher retail fish prices. As things stand now, coastal areas have a geographic subsidy because of greater availability and consumption of fish there.

Poland catches a lot of squid but it is not eaten in Poland and the EEC has a high tariff on squid. The price of squid is very low in Poland in order to make it economically attractive and there is a small education program whose aim is to inform people how to cook squid and other seafood not traditionally eaten.

Poland sells jack mackerel, blue whiting, hake, and sardinella to African countries, but Rybex expressed concern about port congestion and unsureness of payment.

Cost of fuel, not wage increases, is the most significant source of increased costs for the Polish fleet. Fuel must be paid for in hard currency. Older ships with less powerful engines can fish off Norway or Africa but those in the Pacific or Antarctic need powerful engines which consume large amounts of fuel.

The head of the Odra fishing company bemoaned the fact that Polish vessels were not permitted to offload or transship in U.S. ports fish caught on the high seas. He felt that the protection afforded to U.S. fishermen by this law was no longer applicable because of the existence of the 200-mile limit and the present system of U.S. fish allocation. He stated that the law caused several problems for the Poles. First, it resulted in considerably higher transport costs as fish usually had to be transported to a Polish port. Second, the quality of the fish suffered from excessive handling.

Eight of Odra's 48 ships and 4 of Gryf's 27 ships fish in U.S. waters. In addition, Dalmor has boats in U.S. waters. These three fishing companies and Transocean (the company whose vessels supply the fishing fleet) use Vancouver, B.C., as their port for repairs, supplies, fuel, etc. The head of Odra, however, reportedly would like to use Seattle, Wash., and/or other U.S. west coast ports for these services.

Fishing crews are changed every 5 months. Odra alone spends over $800,000 annually on supplies and repairs in Vancouver and an additional $2,500,000 on fuel. Gryf spends about half of these amounts, and Dalmor and Transocean spend considerable sums as well.

EEC Lowers Tariffs on Cod and Whiting Imports

From 1 January to 31 December this year, the EEC will allow a total of 2,000 metric tons (t) of whiting, *Merluccius bilinearis,* whole, headless, or in pieces, to enter the EEC at the reduced tariff rate of 8 percent instead of the normal import tariff rate of 15 percent. A complicated share-out system was established to determine each Member State's allocation, primarily using estimates of the previous year's needs and usage.

Two installments were established: The first installment of 1,310 t was implemented 1 January 1981; a second installment of 690 t will constitute a reserve which will be drawn on by Member States after they have used up their initial share out.

The first installment of 1,310 t is as follows: Benelux (Belgium, Holland, and Luxembourg), 10 t; Denmark, 305 t; Germany, 552 t; Greece, 1 t; France, 194 t; Ireland, 5 t; Italy, 9 t; and the United Kingdom, 234 t.

In a similar decision, the EEC is allowing 10,000 t of frozen cod fillet imports to enter the EEC at a reduced tariff rate of 8 percent instead of the normal import tariff rate of 18 percent. In the first installment, 61 percent of the quota is allocated to Member States according to historic usage with the remaining 39 percent constituting the reserve. As a Member State exhausts its initial allocation, it will be allowed to draw on the reserve until the 10,000 t quota is exhausted.

The initial quota allocations for each Member State are: Belgium, Holland, and Luxembourg, 25 t; Denmark, 500 t; Germany, 1,800 t; Greece, 5 t; France, 1,000 t; Ireland, 5 t; Italy, 10 t; and the United Kingdom, 2,500 t.

Uruguayan Fish Catch and Exports Climb

Uruguayan fishermen reported a record catch of 120,000 metric tons (t) in 1980 even though they have to pay some of the world's highest prices for diesel fuel. They were also expected to set another catch record in 1981.

Catch

The Uruguayan fishing industry in 1981, unlike the industry in neighboring Argentina, has had an excellent year despite some problems which developed in 1980. The weather in early 1980 was unusually warm and affected the annual migration of hake, the most important species Uruguayan fishermen catch. When the hake finally reached the coastal grounds, it appeared in record quantities. This catch in 1980 was so large that processing plants were unable to handle the quantities landed. The hake catch in 1981 was also reported good. The Uruguayan Government was concerned, however, about sea trout stocks and had reportedly closed that fishery until 1982. Even so, most local observers believed that fishermen would again set new catch records, perhaps reaching as much as 150,000 t (Table 1). The significant catch increase since 1975 has made the Uruguayan fishing industry one of the most rapidly growing in the world.

Table 1.—Uruguay's fish catch and fishery exports, 1975-1981[1].

Year	Catch[2] in 1,000 t	Exports	
		Amt.[3] (1,000 t)	(US$1 million)
1975	26.2	8.0	3.4
1976	33.6	11.0	5.2
1977	48.3	17.7	10.3
1978	74.2	32.7	22.5
1979	108.1	47.8	36.2
1980	120.0	67.0	50.0
1981[4]	150.0	75.0	60.0

[1]Source: FAO "Yearbook of Fishery Statistics," 1979 (1975-79 data) and U.S. Embassy, Montevideo, for 1980-81 data.
[2]Live weight.
[3]Product weight.
[4]Projection.

Fuel Prices

Uruguayan fishermen have to pay some of the highest prices in the world for diesel fuel. Almost all of Uruguay's fuel has to be imported and the country has serious balance of payments difficulties. Industry trade associations are extremely critical of the government's failure to provide more relief from the high fuel prices. They especially complain that the Argentine fishermen with whom they compete are able to buy fuel at cheaper prices and receive higher export subsidies. Even though the Uruguayan Government had been rebating 40 percent of fuel costs to the fishermen, they still complained of the extensive paperwork required.

Domestic Market

A very small part of the Uruguayan catch is marketed domestically. In 1979, about 13,500 t, or 12 percent of the catch, was sold in Uruguay. A decline in beef prices in 1980, however, adversely affected 1980 fishery sales, because many consumers apparently increased purchases of relatively cheaper beef.

Exports

The Uruguayan fishing industry is dependent on foreign markets; from 85 to 90 percent of the catch is generally exported. Export shipments have increased rapidly in recent years and may have hit $60 million last year (Table 1). Uruguayan exporters were concerned that high interest rates in the United States were affecting export sales. United States importers were having difficulty financing imports and turned to cheaper domestically caught species. Uruguayan exporters were also affected by higher import duties placed on fishery imports by Brazil. The latter was reportedly trying to protect its domestic poultry industry. Brazilian consumers increased fish consumption because of rising poultry prices. Even with these problems, exporters continued to increase export shipments. Local observers reported in early 1981 that Uruguayan exporters were finding a ready market at higher prices. (Source: IFR-81/122.)

France Helps Finance Salvadoran Tuna Port

France is helping El Salvador build a modern tuna port at La Union, a port on the Gulf of Fonseca. The French Government in 1978 helped El Salvador finance the first stage of the project, constructing a 250 m pier and 10,000 m^3 cold store at La Union and purchasing two tuna purse seiners.

The French Government has now secured additional loans for El Salvador from French Government agencies and banks at preferential interest rates. The Bank of Paris and other banks are loaning $38.8 million at 7.5 percent interest. The French National Credit Institution is loaning $8.4 million at 3.5 percent interest. The Bank of Paris is also loaning $6.8 million at 1.75 percent interest. These funds have already been disbursed to French and Salvadoran subcontractors who have been awarded contracts for both planning and construction.

The Salvadoran Government is now negotiating another substantial loan to continue the expansion of the port. Information on the current status of these negotiations is not yet available. The port was originally scheduled to open in 1981, but various difficulties have reportedly delayed construction, and the port will now probably not be opened until sometime later this year.

Three French companies have been the primary contractors in the La Union project. Ornium Technique Urbanisme et Infrastructure and SOFREMER have planned the project. Morillon Corcol Courlot Enterprise has supervised the construction. SOFREMER has also been responsible for ordering the 69 m purse seiner *Justicia* from the French shipyard Ateliers et Chantiers de la Manche. The *Justicia* is currently operating off El Salvador with a French crew. Local sources estimate that it can catch over 3,000 t of tuna annually. A second purse seiner is still under construction in a French shipyard.

France is the only country involved in

the port construction project at La Union. The Canadians are training fishermen at La Union, but as part of a separate project. A U.S. tuna company had signed a contract to buy tuna at $1,200 per ton for the remainder of 1981. The Salvadoran Government estimates that landings at La Union (tuna and other species) will total $16 million in the first year of operation, and $19 million and $21 million in each succeeding year. (Source: IFR-81/139.)

Fish Research Off Chile, Peru, and Ecuador Funded

The Inter-American Development Bank (IADB) has announced the approval of a $977,000 technical cooperation grant to help carry out a research program to determine the availability and productivity of pelagic fishes off the coasts of Ecuador, Peru, and Chile. The technical cooperation was extended from the Fund for Special Operations.

The southeastern Pacific is one of the more productive marine areas in the world, notes the IADB, producing pilchards, jack mackerels, Pacific mackerels, etc. Although existing data indicate that fishing potential of these three species is greater than current levels of exploitation, more complete information is needed to ensure that investments in future exploitation will avoid the risk of overfishing.

The project is designed to determine the availability and productivity of the pelagic species in an area of approximately 100 n.mi. beyond the coasts of Ecuador, Peru, and Chile. It will consist of two exploratory research expeditions which will be carried out for periods of 30 days each during two different seasons of the year, as well as a research program on population parameters.

The objective of the expeditions is to determine the biomass and maximum sustainable yield of the pelagic species, the distribution and concentration of the shoals of these species, their biological characteristics, and their environment. The expeditions will be carried out simultaneously in the three countries by a research ship supported by two commercial fishing boats per country. The population parameter study, to be carried out along with the fishing expeditions, will supplement the biomass figures in the computation of accurate estimates for the potential catch.

The Bank resources will finance the expenditures related to the research expedition, rental of the two fishing boats, the research on population dynamics in Ecuador and Peru and the acquisition of equipment, and related features of the project. Bank funds will also be used to contract a consultant to review the work program and other preliminary activities to hire institutions and obtain the services of a specialized firm to carry out supervisory functions of the project.

The total cost of the project is estimated at $2,286,000, of which the Bank's technical cooperation will cover $977,000, Ecuador $653,000, and Peru the remaining $656,000.

FAROESE FISHERY EXPORTS LISTED

The Faroe Islands, self-governing but under Danish jurisdiction, are located in the northeastern Atlantic between the United Kingdom (UK) and Iceland. The Faroese economy is dependent on the fishing industry to provide the export earnings and employment for the Islands' population of 43,000. Nearly one-tenth of the Faroese working force is employed as fishermen.

The export of fishery products accounted for approximately 92 percent of the $192 million[1] worth of total exports earned during 1980 (Fig. 1). The value of fish and fishery exports increased from $127 million in 1979 to $176 million in 1980, or by 38 percent. The quantity of such exports during 1980 was 176,000 metric tons (t), a 5.5 percent increase over the quantity exported in 1979. One-half of the 1980 export value came from fish caught in Faroese-claimed fishing grounds. Norwegian and Greenland fishing grounds contributed approximately $10 million each to the 1980 Faroese export earnings.

European Community (EC) countries imported nearly 77 percent of the Faroese fishery exports in 1980 with a value of $136 million. Denmark was the largest EC importer and purchased nearly $39 million worth of Faroese fishery products. The 29 percent increase in the value of 1980 Faroese fishery exports to the EC is due to the increase in Faroese saithe (coalfish) production, for which there is a considerable market in the EC. The UK and the Federal Republic of Germany imported $28.9 million and $23.8 million worth of fish and fishery products from the Faroe Islands, respectively.

Faroese exports of fishery products to the United States decreased from 9,240 t in 1979 to 7,219 t in 1980, or by 22 percent. Because of higher prices, however, the export value of Faroese fishery products increased slightly (from $19.9 million in 1979 to $20.3 million in 1980).

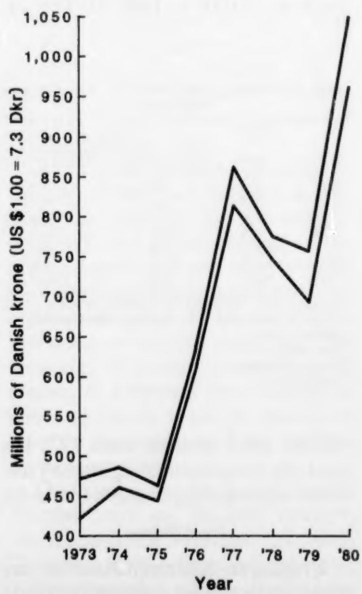

Figure 1.—Faroe Islands fishery and total exports, 1973-1980.

[1]Throughout this report all values are given in U.S. dollars unless otherwise indicated.

Frozen fish fillets accounted for 99 percent of the total U.S. fishery imports from the Faroe Islands. (Source: IFR-81/123.)

Bangladesh Sets New 5-Year Fishery Plan

Bangladesh is reported planning to increase its fisheries catch fivefold by 1985. The major goal of the 1981-85 plan is to substantially increase the number of vessels in the fleet in order to increase the fisheries catch. The largest increase is projected for the inland fisheries (from an estimated 0.6 million t to 2.6 million t). The marine fisheries catch is expected to increase from an estimated 100,000 t in 1979 to 400,000 t in 1985. (Source: IFR-81/138.)

French Tuna Canneries Close

Twenty-four French tuna canneries have discontinued operations during the last 30 years, resulting in over 2,000 lost jobs. The closures were reportedly mostly caused by the transfer of canning operations to the Ivory Coast and Senegal where labor is cheaper and the fishing grounds are closer to processing centers. Low prices of tuna imports from Japan have also contributed to the closings. (Source: IFR-81/138.)

Note: Unless otherwise credited, material in this section is from either the Foreign Fishery Information Releases (FFIR) compiled by Sunee C. Sonu, Foreign Reporting Branch, Fishery Development Division, Southwest Region, National Marine Fisheries Service, NOAA, Terminal Island, CA 90731, or the International Fishery Releases (IFR) or Language Services Biweekly (LSB) reports produced by the Office of International Fisheries Affairs, National Marine Fisheries Service, NOAA, Washington, DC 20235.

EEC Fish Processors Ask for Unrestrained Imports

The EEC fish processors association (AIPCEE) elected a new president, Dirk Ahler, at its annual meeting held last November. Ahler, manager and partner of F. Schottke and Co., Bremerhaven, West Germany, declared that AIPCEE would oppose all protectionist measures which would impede imports on which the European fish community was highly dependent. Protectionist methods such as custom's duties and reference price systems reportedly only increase consumer prices for fish products and discourage increased consumption.

Taiwan's Tuna Fishery off Southern Africa

Taiwan's longliners caught 120,000 metric tons (t) of fish, mostly tuna, in 1980. Most of the catch was taken in the Pacific, but nearly 20 percent of Taiwan's longline catch comes from fishing grounds off South Africa, one of the few countries with which Taiwan maintains diplomatic relations. The waters off the western coast of South Africa also account for half of Taiwan's catch of 29,671 t in the Atlantic Ocean.

Because of South African restrictions on cod, Taiwan has only tuna longliners in this area. Of a fleet of 54 ships in the area, about 30 are permanently stationed there while the others follow the migratory species. In almost all cases, however, because of the almost 7,000 n.mi. between Cape Town and Kaohsiung, the crew live on the ships and are rotated periodically.

In 1980, total landings in South Africa by Taiwanese fishing boats amounted to 14,300 t, about 80 percent of which was albacore. With the price of albacore being over US$2,000 per ton (compared with an average over US$1,000 per ton for other fish), one fishing trip could realize from US$180,000 to US$400,000 in total revenues with a net profit of about one-third of the revenue. Reasons for this high rate of profits include high fish prices caused by the increase in oil prices and cessation of South Africa's surcharges on fuel oil.

Two fishing companies buy and ship the catch to the United States, Europe, and Japan, with the United States being the major market. Almost all of the albacore is transhipped to Puerto Rico, canned there, and then exported to the United States. Italy, Spain, and Japan are the main markets for fish other than albacore.

Taiwan currently has a fleet of 651 tuna longliners with 594 of them active. In 1980, the Atlantic Ocean catch of 29,671 t accounted for 25 percent of Taiwan's total tuna harvest. South African waters provided half of the total harvest in the Atlantic Ocean. One hundred sixty-one ships operated in the Atlantic Ocean in 1980, representing 27 percent of the tuna fishing fleet.

Taiwan signed a bilateral fishery agreement with South Africa on 20 October 1977, just before South Africa's announcement to enforce its 200-mile economic zone. The highlights of the agreement are as follows: 1) The 10-year agreement will expire in 1987, but is renewable; 2) South Africa agrees that Taiwan's tuna longliners can fish within the 200-mile economic zone without any restriction; 3) Taiwan's Government must supply statistics concerning its fishing off South Africa to the Goverment of South Africa; 4) Taiwanese trawlers must apply for prior permission to fish in South Africa's territorial waters; 5) Every ship operating in waters off South Africa should pay US$324 per year for a license; and 6) There is no limitation on catches, except for cod; the cod quota for Taiwanese fishing boats is 2,000 t per year. (Source: IFR-81/83.)

Egypt Plans To Develop Fisheries

Egypt is planning to further develop its fisheries and harvest as much as 700,000 t of fishery products annually. A long-term plan to develop Mediterranean and Red Sea fisheries has been prepared. The Egyptian fisheries catch was 137,000 t in 1979, of which 75 percent came from freshwater fisheries. The United States of America exported 1,990 t of fishery products, worth $5,347,000 to Egypt in 1980. (Source: IFR-81/138.)

Chesapeake Bay Seagrass Problems, Solutions Eyed

Two Virginia Institute of Marine Science (VIMS) scientists, studying why eelgrass beds in lower Chesapeake Bay have drastically diminished during the past decade, are also developing ways to transplant the important seagrass and hasten its recovery, the Institute reports. Robert Orth and Polly Penhale of the Institute are also combining their talents to learn the importance of eelgrass to the production of marine animals in Chesapeake Bay, and the effects of environmental factors (light and temperature) on its growth.

Their work, sponsored by the Chesapeake Bay Program of the Environmental Protection Agency, was reported at the 13th International Botanical Congress in Sydney, Australia. Orth related his theory involving the impacts of grazing snails on eelgrass. "Small marine snails feed on the bacteria, diatoms and algae that grow on eelgrass. This grazing keeps the grass fronds clean, allowing the necessary light penetration to support photosynthesis," he said.

A serious loss of eelgrass in Chesapeake Bay occurred after Tropical Storm Agnes in 1972, when huge quantities of rain drastically lowered salinities in the bay. Fresh water killed the snails, and the eelgrass subsequently became fouled and died without their cleansing action, according to Orth.

"While we have not proved this conclusively, evidence suggests we are on the right track," he said.

Penhale reported to the Botanical Congress the results of a 3-year study of the contributions of seagrasses and associated plants to the overall productivity of a marine ecosystem. Her paper was coauthored by Kenneth Webb and Richard Wetzel of VIMS. A marine plant physiologist, her work also involves studies of the impact of light on seagrass growth, and the community structure of seagrass beds in lower Chesapeake Bay.

Fish-Holding Experiments for Scup Are Reported

Tests of fish-holding systems for whole scup, *Stenotomus chrysops*, aboard the MV *Suzanne Beth* have been reported by the University of Rhode Island (URI) Food Science Department and the URI Marine Advisory Service.

The holding systems were: 1) Boxed in normal vessel ice; 2) boxed in experimental enzymatic ice; 3) chilled seawater using normal ice in a 3:1:0.5 fish, ice, seawater ratio by weight; and 4) chilled seawater using experimental enzymatic ice in the 3:1:0.5 fish, ice, seawater ratio. The control sample was the vessel's normal stowed-in-ice fish.

All tests were carried out over an 18-day period. Quality assessment on all the samples was made with the following methods: 1) Torrymeter, 2) xanthine oxidase enzyme test sticks, 3) ammonia analysis, and 4) organoleptic evaluation. All samples were treated from day 1 of the voyage and all figures refer to holding times post mortem.

Basically, the chilled seawater (CSW) systems using normal and enzymatic ice, showed a higher quality product for a longer period of time than either of the boxed-in-ice systems or the control sample. Sample shelf life was as follows:

1) Scup boxed with normal ice was acceptable at 10 days.

2) Scup boxed with enzymatic ice was acceptable at 13 days.

3) Scup held in CSW using normal ice was still acceptable at 18 days.

4) Scup held in CSW using enzymatic ice was acceptable at 18 days.

The control sample taken from the fish hold was acceptable at 9 days, mainly because of the use of adequate horizontal pound boards keeping the compression loads on the fish to a minimum. Drip loss was checked and found to be negligible, but a softer species, such as whiting, if subjected to high compression loads, will suffer weight loss.

This was the second such experiment in the URI series. The first involved holding butterfish boxed in ice, CSW, and frozen in domestic food freezers on board the vessel, with the control being iced, bulk-held butterfish in the hold. Here, the boxed-in-ice butterfish generally proved to be better over a 10-day period, post mortem.

NY Dedicates Great Lakes Salmonid Hatchery

A new $10 million Salmon River Fish Hatchery at Altmar, N.Y., has been dedicated by the Department of Environmental Conservation. The hatchery, 10 years in planning and construction, will produce 4.5 million trout and salmon, weighing 250,000 pounds, annually for the State's Great Lakes waters.

"These prized salmonids are the foundation of a growing sports fishery," explained Commissioner of Environmental Conservation Robert F. Flacke. "That fishery, in addition to providing top-notch angling for fishermen from across the Northeast, will bring at least $100 million a year into New York's economy and jobs to its citizens.

"Eggs will be taken here, hatched, and fish reared to release size. Those stockings will be of chinook and coho salmon, brown trout, rainbow trout, and steelhead. These fish will grow to huge size on the rich forage fish that exist in Lakes Erie and Ontario . . .

Chinooks will be taken between 25 and 45 pounds. New York's current Lake

Ontario record is 47 pounds. Cohos will range from 8 to 15 pounds, reaching toward our current 21-pound 9 ounce record. Browns will go to 17 and more pounds and steelhead up to 21-plus pounds."

Harvest Practices May Hurt Hawaiian Seaweed

Government controls may be needed to preserve Hawaii's limu (seaweed) industry, according to Jerry Kaluhiwa, director for the Limu Restoration Project near Heeia State Park in Windward Oahu. Limu, especially ogo and manauea (species of *Gracilaria*), is becoming scarce and more expensive, Kaluhiwa said. Limu's scarceness, he contends, partly results from harmful practices of commercial harvestors and from short-sighted marketing.

Kaluhiwa believes governmental action may be needed to save existing limu beds and to protect new ones. Access to limu beds, he said, should be limited to prevent the beds from being destroyed by indiscriminate overharvesting. He cited the problems the restoration project has had with pickers gathering limu from its sites in Kaneohe Bay that it uses to grow seedlings.

"Anybody can come in and pick the limu," Kaluhiwa said. "We can't stop them. All we can do is ask them to pick the limu in the right way so it can grow back." Kaluhiwa also believes that commercial harvesters should be required to go through a licensing process in which they demonstrate the ability to properly harvest limu.

The methods for picking limu so that it may grow out again are simple:

1) Pinch or snip the limu 1½ inches or more above the holdfast, or the base of the stalk. Pinching or snipping the limu any closer to the holdfast may kill the plant;

2) Reset the rock or object to which the limu is attached back into the water's bottom. If the rock is thrown back into the water, the limu may end up face down and die. Also, even if the limu ends right side up, wave action may flip it over; and

Proper limu harvest method.

3) Pick underused species of limu. Many are edible and tasty, and harvesting may help to prevent them from overcrowding the more popular species.

Kaluhiwa suggested that local markets could help ease the pressure on popular limu like ogo and manauea by looking at the retail possibilities for underused species. (Source: *Makai.*)

Seaweed Farm Prospects Noted in Washington Area

According to Tom Mumford, a seaweed expert with the Washington Department of Natural Resources, seaweed is rich in Vitamins B and C and important trace minerals, and it contains between 36,000 and 50,000 units of Vitamin A, which is far more than either chicken eggs or cow's liver.

"Oriental cultures," says Mumford, "have eaten seaweeds for centuries and still consider them as staples in their diet." "Nori" is the Japanese name for a edible seaweed of the genus *Porphyra*, and it is the most widely consumed and most commercially profitable of all edible seaweeds, which, says Mumford, should more properly be called sea vegetables. "In Japan," Mumford points out, "nori culture has become the largest single marine fishery, annually constituting a billion-dollar industry."

In the United States, nori is an imported product, and as might be expected, the main consumers in this country have been among the Oriental communities. Mumford says, however, that imports have recently risen by 40 percent, reflecting a growing interest on the part of other Americans in the benefits of sea vegetables.

At a workshop sponsored by the Department of Natural Resources and the Washington Sea Grant Program last year, the possibilities of developing a nori culture industry in Washington waters were discussed. Out of some 80 species of nori that exist worldwide, Puget Sound contains 16, several of which would be appropriate for culturing.

For the past several months, Mumford and John Merrill of the University of Washington Department of Botany have been conducting research to determine the ideal oceanographic conditions for culturing nori in Puget Sound. According to Mumford, the Department of Natural Resources is setting up a nori demonstration farm, with assistance from Japanese nori farmers. They have been looking at a site in southern Puget Sound near Hartstene Island or McNeil Island. Mumford has also been involved in a Sea Grant-sponsored project aimed at developing net structures for growing seaweed that are able to withstand adverse weather conditions and also determining the tastiest *Porphyra* species found on Washington seashores.

"A commercial nori industry in Puget Sound is still sometime off," says Mumford, "but there is considerable interest in the idea. Oyster farmers, for example, could combine seaweed culture with oyster farming in some areas."

Fishing Under Sail: Learning From the Past

Fishermen and boatbuilders can learn a lot about wind-powered workboats right in their own backyards, according to Mike Alford, of the Hampton Mariners Museum in Beaufort, N.C. Hundreds of fine old sailing workboats have been discarded and are moldering in creeks, sheds, and yards.

Alford has begun a study of the North Carolina's historic boats for the Museum. When he finds a boat with historic importance, he measures it, photographs it, and transforms the lines and contours into detailed blueprints, hoping to eventually compile a reference book for boatbuilders and historians alike.

Alford believes that without the introduction of cheap gasoline in this century, the old classics of the State's fleet would have continued to evolve.

"I believe that what we've seen is a sudden interruption in the natural development of the boat," he says. "We almost, but not quite, lost the art of fishing under sail. We need to go back to the extremely efficient boats of a couple of generations ago, and pick up where we left off."

Alford points to three mainstays in the old North Carolina sailing fleet of workboats:

1) The sharpie, used mainly for oyster fishing along the shallows of the central coast, beginning in the late 1800's;

2) The spritsail skiff, a late-19th century craft used up and down the coast; and

3) The Albemarle shad boat, which may have been indigenous to North Carolina.

Each of the types evolved to suit the locations, fisheries and economic conditions of the times, Alford adds.

Erratum

In the article "Possible temperature effects on charter boat catches of king mackerel and other coastal pelagic species in northwest Florida," 43(8):21-26, the order of authorship was transposed. The correct order is: William A. Fable, Jr., Joe Finnegan, Jr., Harold A. Brusher, and Lee Trent.

New NMFS Scientific Reports Published

The publications listed below may be obtained from either the Superintendent of Documents, U.S. Government Printing Office, Washington DC 20402, or from D822, User Services Branch, Environmental Science Information Center, NOAA, Rockville, MD 20852. Writing to the agency prior to ordering is advisable to determine availability and price, where appropriate (prices may change and prepayment is required).

NOAA Technical Report NMFS SSRF-750. Schwartz, Frank J. **"World literature to fish hybrids with an analysis by family, species, and hybrid: Supplement 1."** November 1981. 507 p.

ABSTRACT

Supplement 1 comprises 1,814 citations published between 1971 and October 1980 which deal with fish hybrids of the world. Continuing the format of the original compilation, each reference has been read, analyzed, and referenced by author, family, species, and hybrid cross.

NOAA Technical Report NMFS SSRF-751. Griswold, Carolyn A. (editor). **"The barge *Ocean 250* gasoline spill."** November 1981. 30 p.

ABSTRACT

On 16 March 1978, the barge *Ocean 250* grounded on Watch Hill Reef 1,006 m off Watch Hill, Rhode Island. An estimated 2.6 million liters of gasoline was spilled into Block Island Sound.

Results of cytogenetic analyses indicated maximum damage occurred in fish eggs collected in plankton and neuston samples in the spill area. Membrane or embryo damage occurred in up to 100 percent of the fourbeard rockling, *Enchelyopus cimbrius*, and yellowtail flounder, *Limanda ferruginea*, eggs collected over a 4 day period following the spill. Low levels (<12 ppb) of hydrocarbons analyzed in the gasoline range were found in the water column at stations in the spill area 36-40 hours after the spill first began. Zooplankton samples collected from the same area showed traces of hydrocarbons from the gasoline range as did two species of benthic invertebrates, the sea scallop, *Placopecten magellanicus*, and the hardshell clam, *Mercenaria mercenaria*. Twenty-three fish samples representing 10 species were analyzed. Five showed levels twice that of the control sample taken from Fox Island, Narragansett Bay. There was no apparent damage to benthic communities, and analyses of zooplankton communities at the time of the spill and 3 weeks later showed normal patterns of species composition and abundance.

With the exception of localized damage to fish eggs, there was no apparent discernible damage to fish or invertebrate populations in the area immediately following the spill, and although there were measurable amounts of gasoline hydrocarbon components in a small number of water, fish, and invertebrate samples, there is no evidence that this would cause long-term damage to the populations. Shore surveys did not indicate damage to intertidal flora and fauna along Fishers Island, New York, or along the southern Rhode Island coastline.

NOAA Technical Report NMFS Circular 441. Palko, B. J., G. L. Beardsley, and W. J. Richards. **"Synopsis of the biology of the swordfish, *Xiphias gladius* Linnaeus."** November 1981. 21 p. No abstract.

Tuna Commission Prints Eight Species Synopses

The Inter-American Tropical Tuna Commission (IATTC) has announced publication of its Special Report No. 2, **"Synopses of Biological Data on Eight Species of Scombrids."** Edited by William H. Bayliff, the 530-page volume is an updated English version of a Spanish volume on the eight scombrids prepared by IATTC scientists for the Comision Permanente del Pacifico Sur.

These synopses follow the format established by and for those published under Food and Agriculture Organization and cooperating agency auspices. They differ primarily in that taxonomic data has been placed in a separate chapter rather than being listed with each species. Most of the synopses use only data obtained from Pacific Ocean studies, except that for *Thunnus maccoyii*, for which data from the Southern Ocean is included.

Following a brief introduction by Bayliff, Withold Klawe ably reviews the "Classification of tunas, mackerels, billfishes, and related species, and their geographical distribution" ($0.50). Thereafter come synopses on the albacore tuna, *Thunnus alalunga*, by Terry J. Foreman ($1.50); yellowfin tuna, *Thunnus albacares*, by Jon S. Cole ($2.00); southern bluefin tuna, *Thunnus maccoyii*, by Robert J. Olson ($1.50); bigeye tuna, *Thunnus obesus*, by Thomas P. Calkins ($1.50); northern bluefin tuna, *Thunnus thynnus*, by Bayliff ($1.00); skipjack tuna, *Katsuwonus pelamis*, by Eric D. Forsbergh ($1.50); black skipjack tuna, *Euthynnus lineatus*, by Arturo F. Muhlia-Melo ($1.00); and the chub mackerel, *Scomber japonicus*, by Kurt M. Schaefer ($1.50). The volume winds up with an extensive 83-page bibliography ($2.00).

A handy reference, the complete book can be ordered from the IATTC editor, c/o Scripps Institution of Oceanography, La Jolla, CA 92038, for $12. Each chapter can also be ordered at the prices listed above.

Netherlands Antilles Fishery Report

The U.S. Regional Fisheries Attache for Latin America, Charles Finan, traveled to the Netherlands Antilles last year to assess the local market for U.S. fishery exports. He found a large, unsatisfied market for species which are underutilized by fisherman in the southeastern United States, although local price controls could make it difficult for U.S. exporters to increase shipments. Finan has prepared an 8-page report on his findings which can be obtained by requesting IFR-81/136, "The Fisheries of the Netherlands Antilles," from NMFS Statistics and Market News Offices. Please enclose a self-addressed envelope with $0.35.

Foreign Fishing Regulations Noted

A majority of coastal countries have extended their national jurisdiction over fisheries to 200 miles. Many are now in the process of revising their policies toward and legislating control over management and development of fisheries in their extended zones of jurisdiction. The FAO has prepared a 411-page compilation of national legislation relating to coastal state controls over foreign fishing. The FAO report includes an introductory analysis of state practice in the establishment and implementation of "200 mile" jurisdictions over fisheries and a series of tables presenting coastal state requirements for foreign fishing.

A copy of the report can be purchased for $27.00 by ordering FAO Legislative Study No. 21, "Legislation on Coastal State Requirements for Foreign Fishing," document number 0088-F2035, from UNIPUB, P.O. Box 433, Murray Hill Station, New York, NY 10016.

A New Fisheries Research Journal

Publication of a new journal, *Fisheries Research*, has been announced by Elsevier Scientific Publishing Company, P.O. Box 211, 1000 AE Amsterdam, The Netherlands. Its stated purpose is "to provide a truly international forum for the publication of research results and other relevant information in the three main areas of fishing technology, fisheries science, and fisheries management." The editor, G. L. Kesteven of Australia, is considering papers related to saltwater, brackish, and freshwater systems, including reservoirs.

The initial issue, November 1981, measuring 6×9 inches, contained 81 pages, with articles on reactions of fish to electrified barriers and bubble curtains, the drag of four-panel demersal trawls, a towed instrument package for fisheries research, efficiency of the Scottish creel and the inkwell pot in crab and lobster capture, and a life table and biomass estimate for Alaskan fur seals. Quarterly, the journal costs US$59.25 per year.

Report on Swedish Fisheries in 1980

Both the quantity (220,000 t) and the value ($95 million) of the Swedish fisheries catch increased during 1980 by approximately 16 and 10 percent respectively compared to 1979 levels. Substantial increases in the herring and cod catch contributed to this overall increase. Operating costs, however, increased in 1980 and depressed earnings of Swedish fishermen and fishing companies. Freshwater fishermen faced the problems of acidification of lakes and rivers and of competition from recreational fishermen. The expansion of the seafood processing industry has been undertaken in hopes of achieving self-sufficiency in this sector. It is also expected that the demand for fish intended for human consumption will increase as a result of the anticipated Government move to reduce or abolish subsidies for meat which will increase its price.

The U.S. Embassy in Stockholm has prepared a 16-page report on Swedish fishery developments during 1980. A copy of the report can be ordered for $5.00 by requesting report number PB-81-226-318 from the U.S. Department of Commerce, NTIS, Springfield, VA 22161.

New Volume Explores Marine Problems

"The Oceans: Our Last Resource," by Wesley Marx, has been published by Sierra Club Books, 530 Bush Street, San Francisco, CA 94108. Marx, who authored the earlier book "The Frail Ocean," reiterates a number of myths and facts about the sea and its resources and proposes a variety of ideas for increasing marine harvests, safeguarding the seas, restoring wetlands, etc.

Some of the problems touched upon include ocean dumping, overfishing, marine research within the 200-mile zones of foreign nations, coastal congestion, beach erosion, seabed mining, wetlands drainage, sewage dumping, etc. The main thesis seems to be that the oceans face a "critical turning point."

The book is written in a popular style for a very general readership (some chapters appear to have been published earlier in a variety of magazines) and merely reiterates much that is already well known or has already been proposed without providing much in the way of new insights.

The 352-page volume costs $13.95 and is available from the publisher.

A Guide to Pacific Coast Inshore Fishes

"Pacific Coast Inshore Fishes," by Daniel W. Gotshall, has been published by Sea Challengers, 1851 Don Avenue, Los Osos, CA 93402 as a greatly updated and expanded version of the older "Fishwatchers' Guide to the Inshore Fishes of the Pacific Coast."

The author, a professional marine biologist and noted underwater photographer, has added 33 more species, bringing the total covered to 126—all but four in excellent, four-color photographs. For this edition, new color separations have been made and the life history, geographical, and depth range data for each species are updated.

Listed for each species is its nomenclature, range, depth, habitat, size, and distinguishing characteristics. Generally, the species depicted are found in depths between 10 and 150 feet and they range from southeastern Alaska to Baja California. Some intential omissions include the more commonly known game and commercial species.

An illustrated family key will help those less experienced in fish identification to identify specimens. While the book is basically pitched at novice anglers, scuba divers, or beachcombers, the handsome photographs will also be appreciated by and useful to readers more technically inclined. The book also contains a good illustrated glossary and is indexed by species.

Printed on heavy, high-quality paper stock, the 96-page volume, 7×9 inches, is available from the publisher for $11.50 (paperbound) and $22.95 in a limited (200) hardbound edition.

Report on UK Fish Consumption Available

A major frozen foods company in the United Kingdom (UK), Ross Foods Limited, published a 1981 study of consumer attitudes toward fishery products consumed in the UK during 1980.

The basic conclusions of the 24-page booklet, entitled "The Ross Report on Fish," are that British housewives still consider fish a good buy, that consumers regard fish as a prime source of good nutrition, and that young consumers (15-34 years old) are beginning to serve fish more frequently, even though prices have risen sharply in recent years.

In the last 20 years, consumption of frozen fish in the UK has increased by 47 percent, whereas the consumption of fresh fish has decreased by 32 percent. The marketing of fishery products and consumer preferences with regard to different fish species are also described in the report. Copies of this report may be obtained on a first-come, first-served basis by sending a preaddressed envelope (9 × 12 inches) with $0.60 postage to: Milan Kravanja, Chief, Foreign Fisheries Analysis Division, NMFS, NOAA, Commerce, Washington, DC 20235.

A Caribbean Marine Research Center Directory

The United Nations Environmental Program (UNEP) and the Intergovernmental Oceanographic Commission (IOC) published an extensive report in 1980 listing 144 marine science research centers throughout the Caribbean. Detailed information, including the name; address; executive officer; scope of research; description of projects; mission, organization, future plans, cooperative projects, provisions for visiting scientists, personnel, facilities, vessels, and publications; and other information is included for 77 of the centers listed.

A copy of the report can be obtained by requesting "Directory of Caribbean Marine Research Center" from the Activity Center, Regional Seas Programme, United Nations Environmental Programme, Office of Geneva, Palais des Nations, 1211 Geneva 10, Switzerland. Information on the cost of the report, if any, is not available. (Source: IFR-81/135).

Report on Foreign Fisheries Available

The Ocean Policy Committee of the U.S. National Academy of Sciences has published the proceedings of a workshop held by the Scripps Institution of Oceanography in La Jolla, Calif. during January 1981. The proceedings deal primarily with international development and research and include individual country reports on Brazil, Egypt, India, Indonesia, the Ivory Coast, Nigeria, Peru, the Philippines, and Thailand.

The report can be obtained free of charge by requesting "International Cooperation in Marine Technology, Science, and Fisheries: The Future U.S. Role in Development" from: Ocean Policy Committee, National Academy of Science, 2101 Constitution Avenue, N.W., Washington, DC 20418.

Editorial Guidelines for *Marine Fisheries Review*

Marine Fisheries Review publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 12, "A List of Common and Scientific Names of Fishes from the United States and Canada," fourth edition, 1980. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

Tables and Footnotes

Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

Literature Citations

Title the list of references "Literature Cited" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, the year and month and volume and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

Citations should be double-spaced and listed alphabetically by the senior author's surname and initials. Co-authors should be listed by initials and surname. Where two or more citations have the same author(s), list them chronologically; where both author and year match on two or more, use lowercase alphabet to distinguish them (1969a, 1969b, 1969c, etc.).

Authors must double-check all literature cited; they alone are responsible for its accuracy.

Figures

All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8- × 10-inches, sharply focused glossies of strong contrast. Potential cover photos are welcome but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

Line art should be drawn with black India ink on white paper. Design, symbols, and lettering should be neat, legible, and simple. Avoid freehand lettering and heavy lettering and shading that could fill in when the figure is reduced. Consider column and page sizes when designing figures.

Finally

First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript flat, first-class mail, to: Editor, *Marine Fisheries Review*, Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Bin C15700, Seattle, WA 98115.

The senior author will receive 50 reprints (no cover) of his paper free of charge and 100 free copies are supplied to his organization. Cost estimates for additional reprints can be supplied upon request.

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